

BIOLOGY

9



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BIOLOGY 9



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Section

1

(Origin of Life)



Earth had high temperature and radiation and had frequent and abundant electric discharges. Those were the conditions when first life originated.

INTRODUCTION TO BIOLOGY

In this chapter you will learn:

- Definition and branches of biology
- Relationship of biology with other sciences.
- Explanation of a scientific method with reference to malaria problem.
- Contribution of scientists particularly muslims in the field of biology.
- Impact of application of basic research in biology on human life.
- Islamic and scientific concepts about the origin of life.



To understand and appreciate the nature it is essential to study and observe the fundamental characteristics and role of every thing existing in the universe, especially the structure, function and related aspects of living ones. This knowledge of living things, obtained over a course of time, has provided us information and remedies to human problems regarding health, disease, food etc. This has led to new inventions, innovations and discoveries enabling the human society to improve its quality in social, technical and industrial fields.

1.1 What is Biology

This universe is beautifully, ordered and coordinated in its activities. Every thing here fits into the place it occupies. This universe seems to operate under some principles. In order to understand these principles some experiments are done and observations are made, on the basis of which logical conclusions are drawn. Such studies are called science. So the science, in a way, is the study of nature. **Biology** is the scientific study of living things. The word biology has been derived from two Greek words **bios**, meaning life, and **logos**, meaning thought, discourse or reasoning. In biology all aspects of living organisms are discussed.

Biology, with respect to various large groups of organisms is divided into three major branches i.e. Microbiology, Botany and Zoology. In **Microbiology** we study microscopic organisms such as viruses, bacteria, microscopic algae, some fungi and protozoa. **Botany** deals with scientific study of plants and in **Zoology** animals are studied.

The study of biology, apart from other information on life, also provides us answers to the following questions.

1. What are the various kinds of organisms existing on earth and how are they related to the extinct organisms?

2. How can identification and classification of organisms be made with reference to their similarities and differences?
3. What are the body structures of organism and how do they perform different functions?
4. How are the biological characters of organisms transferred from generation to generation?
5. How do organisms live (individually or in groups) and what is their relationship with the environment?

1.2 Branches of Biology

Keeping in view the study of different aspects of organisms, biology is also divided into following branches.

Morphology

It deals with the gross examination of the form and structure of an organism. If we study the external parts of the organism, it is called external morphology and when we make a study of the internal parts of the organism, it is called internal morphology or **anatomy**.

Histology

Microscopic study of tissues is called histology.

Cell Biology

It is the study of structure and functions of cells and their organelles.

Physiology

It is the study of functions of different parts of organism.

Ecology

It is the study of relationships between organisms and their environments. It is also called **environmental biology**.

Taxonomy

The branch of biology, which deals with classification and scientific naming of organisms, is called taxonomy. It deals with natural placement of organisms on the basis of their similarities and differences in structure and some other characteristics.

Embryology

Embryology is the study of the progressive developmental changes starting from zygote, which must be undergone before an organism is born or hatched. The stage between zygote and newly hatched or born baby is called embryo.

Genetics

Genetics is the study of gene and biological inheritance of characters from parents to their offspring.

Palaeontology

It is the study of fossils and their relationship to the evolution of life on earth. Fossils are the dead remains of the ancient organism preserved in rocks. **Palaeobotany** is the study of plant fossils while the study of fossils of animals is called **palaeozoology**.

Biochemistry

This branch deals with the study of all the underlying chemical processes which form the basis of activities of organisms. These activities are called metabolic activities. These can be destructive like respiration and digestion of food or can be constructive like assimilation of food and photosynthesis.

Biotechnology

It deals with the practical application of organisms and their components for the welfare of mankind e.g disinfections and preservation of food, preparation of Insulin and biogas from bacteria etc.

1.3 The relationship of Biology with other Sciences

In ancient times, the scientific information was not classified into the different branches of science as it exist today like biology, physics, chemistry and mathematics etc. All the scientific information was therefore included under one head "Science", but with the passage of time, scientific information increased manifold and this enormous scientific knowledge was then classified into different branches like physics, chemistry, biology, mathematics etc. However, even today the interrelationship of these branches cannot be denied.

As this universe has both living and nonliving things, every branch of natural science deals with the living as well as nonliving things. Thus there is the physics of living things as well as the physics of nonliving things. There is a chemistry of living things as well as the chemistry of non living things, so the biology includes information on various aspects of living things which pertain to the other disciplines of science as well. This forms the basis of interdisciplinary science. This interrelationship has been shown in figure (1.1).

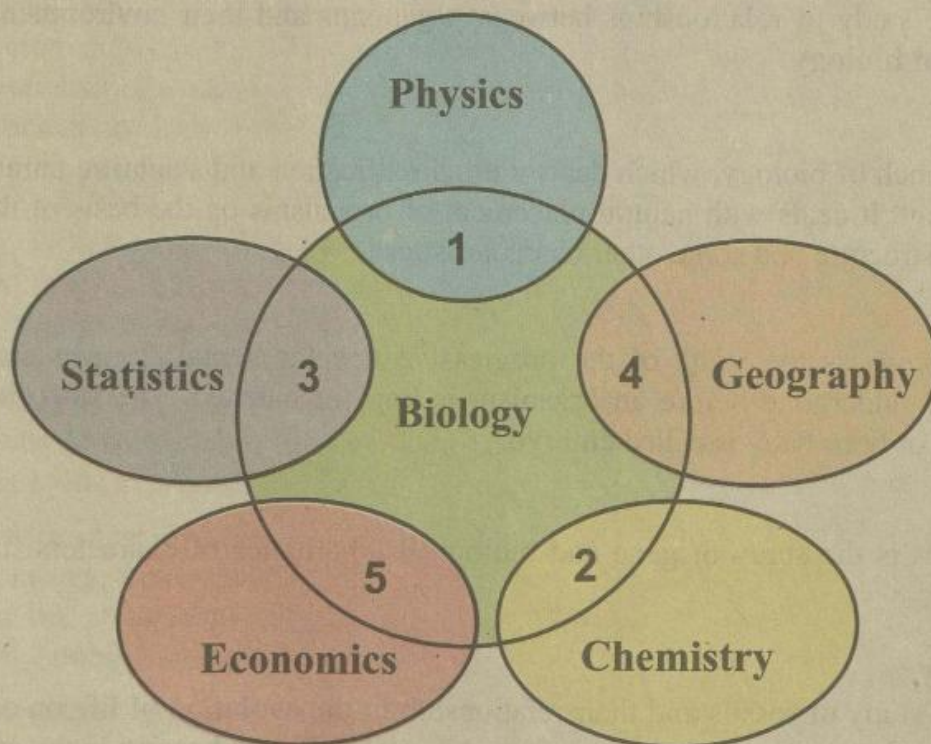


Fig 1.1: Relationship of biology with other sciences

1. Biophysics

It deals with the study of principles and laws of physics, which are applicable to the biological phenomena; for example movement of muscles and bones follows the principles of physics.

2. Biochemistry

The study of different chemical compounds found in organism and the underlying chemical processes in living organisms is called biochemistry.

3. Biometry

The data collected from experiments and observations made on organisms, is analyzed by various methods of statistics, this is called biometry.

4. Biogeography

It deals with the study of occurrence and distribution of different species of plants and animals in the different geographical regions of the world.

5. Bio-economics

It deals with the study of organism from economic point of view. It includes the study of the cost effectiveness and viability of biological projects from commercial viewpoint.

1.4 Biological Method of study

Science is an organized and systematic knowledge, which is gathered through observations, inquiry and experiments. In order to resolve a specific biological problem certain scientific method is adopted, in which conclusion or answers to various related questions of the biological problem are drawn from observations and experiments. Summary of this method is explained in the flow chart (fig 1.2). Let us study malaria as an example of biological problems to understand this method.

Observations

After determination of the specific biological problem, observations are made to collect relevant information or data.

Malaria is a dreadful disease whose history goes back to the pre-birth time of Christ. In ancient days there was no treatment of malaria and large number of people used to die due to this disease. The downfall of Greek and Roman empires has been attributed to this disease by some historians.

The scientists were struggling to know the cure or treatment of this disease from ancient times. In those days bark of cinchona tree was considered to be an effective remedy against malaria. At the same time the bad air (thus the name malaria) coming from stagnant ponds was considered to be a possible cause of malaria. Some volunteers drank dirty water from the ponds to ascertain the cause but failed. In 1878, a French army physician named Laveran, found small microscopic thread like organisms in the blood of malaria patients. These thread like organisms were not present in the blood of healthy person. He called this microorganism as malarial parasite which was later described and given the name -*plasmodium*. By this time four major observations pertaining to malaria had been recorded.

- i. Malaria and marshy places were some how associated.
- ii. Quinine from cinchona bark was an effective remedy for malaria.
- iii. Malarial patients always have malarial parasite in their blood.
- iv. Drinking marshy water did not cause malaria.

Word malaria is derived from two Latin words **mala** means bad and **aria** means air.

2. Hypothesis

Observations alone do not usually provide solution to the scientific problems. In most of the cases one or more suitable propositions are made on the basis of the observations. These propositions are called hypotheses (singular: hypothesis). The hypotheses are tested by scientific methods and the scientist hope that one of the hypothesis would turn out to be the solution of the scientific problem under study.

- A good hypothesis has the following merits.
It is close to the observed facts.
- The deductions can be drawn from it.
- The deductions should be suitable for testing experimentally.
- Results whether positive or negative should be reproduceable.

Every year about 200 million people get malaria, plus about two million die of it in which most of them are children and pregnant women.

Different causes for malaria were proposed but the most suitable hypothesis framed was:

“ Plasmodium is the cause of malaria ”

A hypothesis usually cannot be directly tested. For this purpose, therefore, some deductions are made from the hypothesis, these deduction are put to test through experimentation.

3. Deduction

The logical conclusion drawn from a hypothesis form deductions. Many deductions may be drawn from a hypothesis.

Testing one deduction and finding it correct does not necessarily mean the hypothesis is correct. The validity of hypothesis is more supported if many deductions confirms the hypothesis. Following deduction was drawn from the above-mentioned hypothesis:-

Symptoms of Malaria: High fever(106°F) with shivering. Headache and nausea. High breathing rate with increased heart beat. Heavy sweating some time after high fever leading to normal or even below normal temperature. Person feels fatigued and exhausted. Recurrence of all above symptoms after specific intervals in absence of proper treatment.

“If plasmodium is the cause of malaria, then all persons ill with malaria should have plasmodium in their blood”.

Deduction can be tested and verified by experiments.

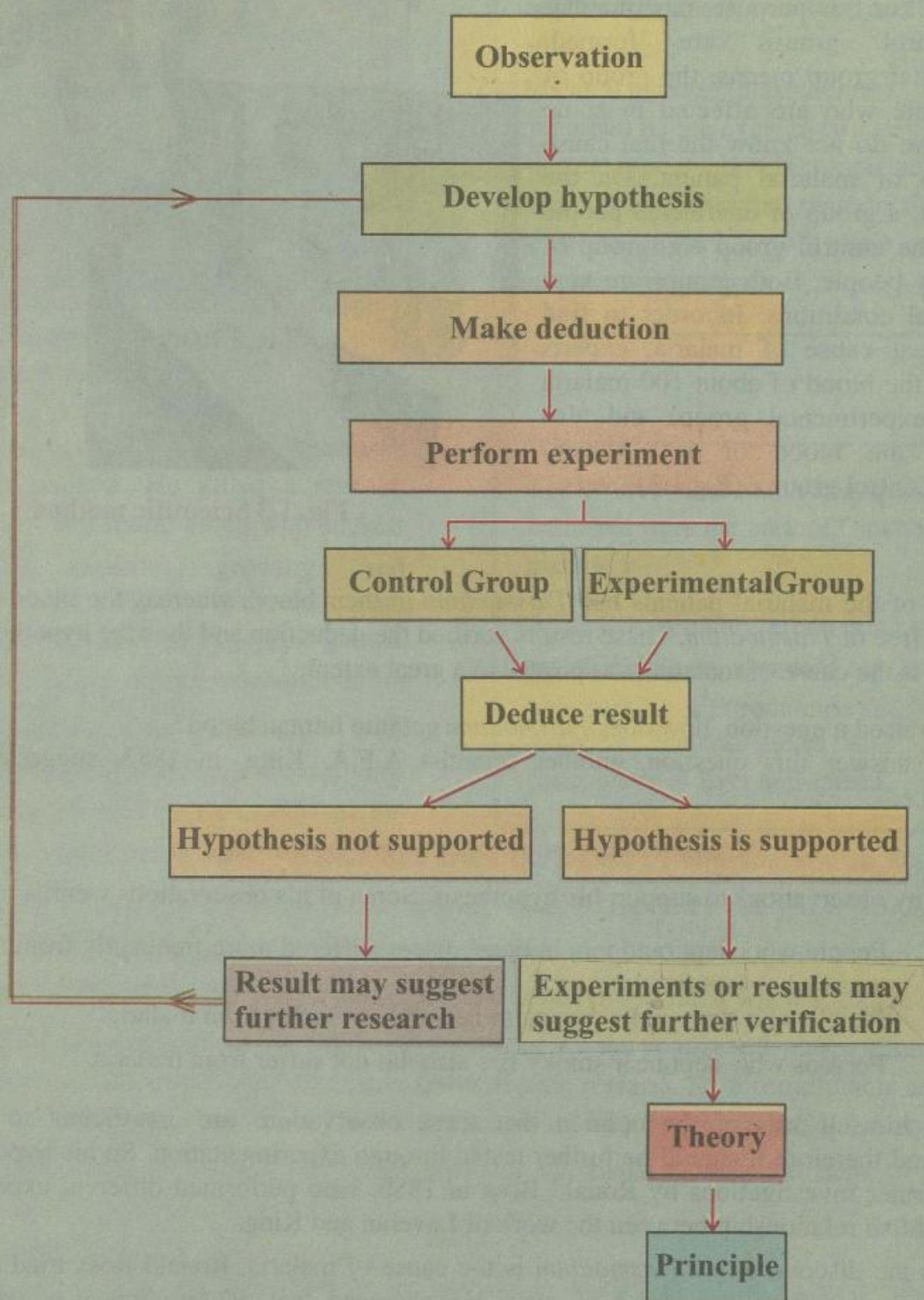


Fig.1.2 Different steps of scientific method

4. Experiments

As has been explained earlier, experiments are designed to test the deduction. For this purpose experimental and control groups are formed. Experimental group means, the group of those people who are affected in some way and we do not know the real cause e.g. group of malarial patient. On the other hand, a group of unaffected people is called the control group e.g. group of the healthy people. Both groups are kept in identical conditions. In order to find out the real cause of malaria, experts examined the blood of about 100 malaria patients (experimental group) and also examined the blood of 100 healthy persons (Control group). (Fig.1.3)

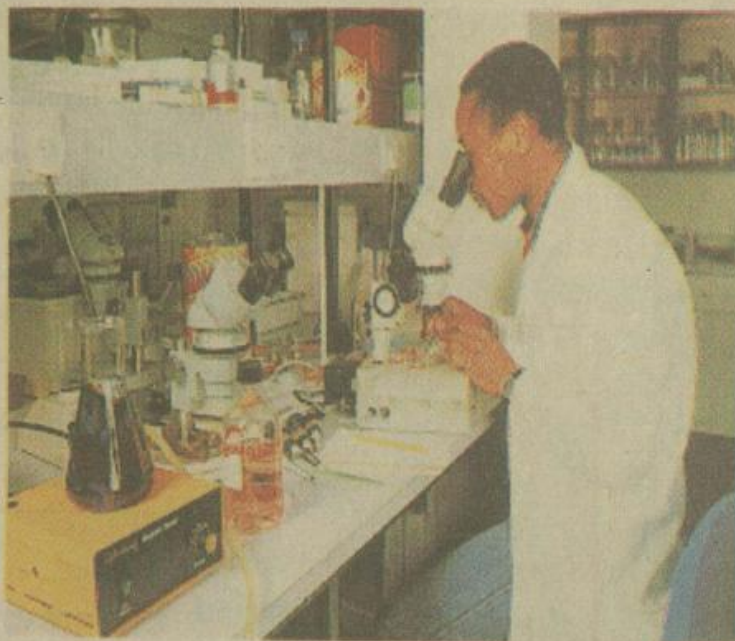


Fig. 1.3 Scientific method

5. Results

Most of the malarial patients had *Plasmodium* in their blood, whereas the blood of healthy persons was free of *Plasmodium*. These results verified the deduction and thus the hypothesis i.e. the *Plasmodium* is the cause of malaria, was proved to a great extent.

This raised a question, how does *Plasmodium* get into human blood? In order to answer this question, another scientist A.F.A. King, in 1883, suggested another hypothesis, i.e:

“Mosquitoes are involved in spreading the malaria”

He listed many observations to support his hypothesis. Some of his observations were: -

- (i) People who slept outdoors in open spaces suffered more frequently from malaria than those who slept indoors.
- (ii) People who slept under mosquito nets did not suffer from malaria.
- (iii) Persons who slept near smoky fire also did not suffer from malaria.

King himself was of the opinion that these observations are insufficient to prove the hypothesis and therefore it should be further tested through experimentation. So his hypothesis was tested by further investigations by Ronald Ross in 1880, who performed different experiments in order to establish relationship between the work of Laveran and King.

After the discovery that *Plasmodium* is the cause of malaria, Ronald Ross tried to find out how *Plasmodium* entered the blood of man. He observed that *Plasmodium* was growing and multiplying (reproducing) in the stomach of female *Anopheles* mosquito who had bitten a person ill with malaria. Ross avoided direct experimentation on man as malaria was a fatal disease and have no treatment at that time. Therefore he selected sparrows instead of man for his experiments due to the identical symptoms of malaria in both.

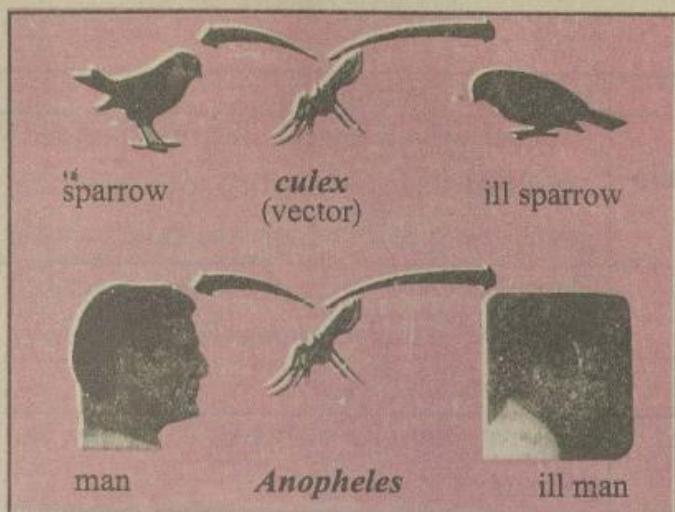


Fig. 1.4 Investigation about malaria on man and birds

He allowed the mosquitoes to bite sparrows suffering from malaria. He killed a few of those mosquitoes and found along with sucked blood, malarial parasites, growing and multiplying in the wall of stomach, from where it later migrated to salivary glands. He then allowed these carrier mosquitoes to bite healthy sparrow, who became ill with malaria and *plasmodium* was found multiplying in its blood. Ross proved that mosquito was the

cause of malaria which transferred *plasmodium* from the blood of one sparrow to another. He suggested that similar relationship might exist between man, mosquitoes and *plasmodium*. After a couple of years this was confirmed by some Italian Scientists.

In this way King's hypothesis was supported and it was proved that when a female anopheles mosquito carrying plasmodium in her body, bit a healthy person it injected plasmodium into the blood of man with its saliva and person became infected with malaria. So mosquito acts as a vector in malaria. In this way, scientists discovered the relationship between man, mosquito and malaria (plasmodium), resolving an ancient biological problem i.e, malaria with the help of scientific method. (Fig. 1.4)

Theory

When a hypothesis has been proved by consistent results of many experiments, then it becomes a theory. A good theory tends to explain the broad based facts or generalizations.

Scientific Principle

When a theory can explain many natural phenomena and is consistently supported by experiments, and also universally accepted by the scientists it becomes a scientific principle.

Word vector means transmitter. Any organism which carries a parasite and transfer it from one person to another is called vector

Malarial parasite (plasmodium) completes its life cycle in two steps. Asexual reproduction is completed in human body and sexual reproduction is completed in the body of female anopheles mosquito.

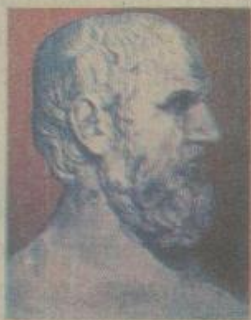
For the treatment of malaria, quinine extracted from the bark of Cinchona plant is used.

Apart from quinine certain other anti-malarial drug are also used for the treatment e.g. chloroquine and poludrin.. Malaria effects the functioning of liver and spleen.

1.5 Historical aspects of Biology

No	Name of Scientist	Period	Books	Important Contribution
1	Aristotle	322-384 B.C	Historia Animalia	Founder of biological classification and classified the animals into two units i.e. genus and species which was called oedus.
2	Theo Phrastus			He discovered sex in plants and described about five hundred plants. He is known as the founder of Botany.
3	Jabar-bin-Hayan	722-817 A.D	Alnabatat and Alhaywan	He wrote number of books on plants and animals.
4	Abdul Malik Asmai	741 A.D	Al-Kheil, Al-Ibil, As-Sha, AlWahoosh, Khalaqul Insan	He described the structure and function of body parts of horses, camels, sheep, wild animals and human being.
5	Abu-Usman Umer Aljahiz		Al-Haywan	He described characteristics of 350 species of animals especially he wrote about life of aunts.
6	Al Farabi and Abul- Qasim, Al-Zahravi	870-950	Al-Nabatat Al-Haywanat	Al-Farabi was the author of these two books, where as Al-Zahravi was famous for removing stone from the urinary bladder.
7	Ibn-al-Haitham	965-1039 A.D	Al-Manazir Mizan-ul-Hikma	These two books were translated into Latin, Hebrew, Greek and other western languages. He corrected the Greek conception of vision, locating retina as the seat of vision.
8	Bu Ali Sina	980	Al-Qanoon Fil Tib Al-Shifa	He wrote about plants, animals and non-living things in one book. He was expert in mathematics, astronomy, physics and paleontology.
9	Ibn-al-Nafees			Discussed circulation of blood in human body.
10	Ali Ibne Isa			He described the structure and function of eye and treatment of about 130 eye diseases.
11	Vi Salius	1514-1564		He wrote a book on structure of human body in which he described bones, muscles and organs in detail.

12	William Harvey	1578-1657		Described the circulation of blood in human body.
13	Linnaeus	1707-1778		Father of taxonomy. Developed method of classification for organisms.
14	Schleiden & Schawann	1839		They formulated cell theory.
15	Louis Pasteur	1822-1895		He discovered microbes in the air, which spoils the food.
16	Robert Koch	1845-1910		He discovered bacteria as causes of many diseases like Tuberculosis.
17	Jospeh Lister	1860		The first person to discover antiseptics e.g. Iodine and carbolic acid.
18	Edward Jennar	1796		Discovered the method of vaccination against small pox.
19	Charles Darwin	1859	Origin of Species	Put forward the theory of evolution.
20	Gregor Mendal	1822-1884	Laws of heredity	Experimented on pea plant and laid the foundation of laws of Genetics.
21	William Lawrence and William Henry	1882		Used X-ray crystallography to understand the structure of DNA. They were father and son.
22	James Watson and Francis Crick	1953		They discovered double helix model of DNA and proved that DNA is found in all organisms.



Aristotle



Jabar - bin - Hayan



Joseph Lister



Gregor Mendel



Louis Pasteur



Charles Darwin



Ibn-ul - Haitham

1.6 Impact of Biological Study on Human Life

The scientific information is mostly used to provide better civic amenities, increased food production and to improve health and the quality of life. The present high level achievements of man is largely due the advance biological research. The study of biology is especially important as most of the routine matters of our life revolves around basic biological principles. New discoveries in biology has revolutionized medicine, dentistry, veterinary medicine, public health, animal husbandry, agriculture, horticulture, pest control and other related fields.

1. Food Production

Food has basic importance in our life. Man has revolutionized the agriculture by research in biological fields. The selection of better seeds has led to better yield and better quality of food crops and fruit plants. The yield of wheat, rice, sugarcane and cotton has been enormously increased bringing healthy effect and prosperity.

In this way man has overcome the problems of balanced diet, food shortage and famine. From plants many useful things e.g. furniture, rubber, dyes, sports goods and building materials are manufactured which has played an important role in the economic up lift of man.

2. Control on diseases

Health is a basic necessity of life. Life has been made comfortable and secure due to the biological researches leading to the discovery of new antibiotics for many infectious diseases like plague, cholera, pneumonia, tuberculosis and typhoid. The child death rate (infant mortality) has also been controlled due to the discovery of vaccines for fatal diseases like small pox, polio, tetanus and diphtheria. AIDS is a recent disease, which has produced havoc for mankind. In this disease man's natural resistance and immunities against diseases are destroyed. This dreadful disease is also now being treated to some extent by a medicine called AZT. Similarly many drugs are being used now for cancer treatment.

Many organisms, fungi and bacteria are used for producing drugs like penicillin and streptomycin etc. which are being used in controlling many infectious diseases. Pesticides are being used to eliminate many harmful pests like locusts, flour beetle, termites, fungi, shipworm, etc.

3. Genetic Engineering

Developments in molecular biology have played a vital role in understanding the functioning of human body. Genetic engineering (in which useful genes are inserted into bacteria etc. to obtain the required beneficial results) and biotechnology have made it possible to manipulate hereditary traits and to produce new species. Human gene that makes insulin is inserted into the DNA of bacteria which then synthesize human insulin on commercial bases. This insulin is very useful in the treatment of diabetic patients.

4. Pollution control

Rapid industrialization during the past few decades has resulted in pollution of our surroundings including air, land and water bodies. As a result of this pollution not only human beings but also animal life around us, including wild life are exposed to all kinds of harmful effects and their very survival has been endangered. It is through biological research that we are trying to find out the way to overcome and eventually eliminate the pollutions. Many plants and animals have

been maintaining the balance in our environment for million of years are now at the verge of extinction due to pollution. Many biologists are engaged in research to find out causes and ways to control the pollution. The biology thus, has great impact on us and it has helped in improving the quality of our life.

5. Space biology

During the exploration of space, presence of life on other planets has also been probed into. On Mars some evidence of life has been found which is still under further investigation.

1.7 Origin of Life

1. Islamic Concepts

By the origin of life, we mean the formation of first living thing on this earth. What was this thing like and how did it come into existence. In The Holy Quran, there are many verses which tell us about the origin of life. The most important fact in the teachings of Quran is that Allah is the ultimate creator of every thing whether plants, animals or non-living things.

اللَّهُ خَالِقُ كُلِّ شَيْءٍ وَهُوَ عَلَىٰ كُلِّ شَيْءٍ وَكِيلٌ ○

“Allah is creator of all things, and He is guardian of overall things”.

(Surah Zamar-Ayat 62)

Not only plants, animals and non-livings but also the universe has been created by Allah. Another important fact we get from Quran is that every living thing has been created from water.

وَجَعَلْنَا مِنَ الْمَاءِ كُلَّ شَيْءٍ حَيٍّ ○ ط

“We made every living thing from water”

(Sura Ambia-Ayat 30)

We were never aware of many living things earlier as we know today. The Virues, bacteria, algae, fungi, different kinds of plants, all animals and human are all living things. According to Quranic verses Allah has created all the diverse living things from water.

This message of Quran hints at common origin of all living things. Or we can at least say that all living things have come out from water.

Allah also says in Quran:

خَلَقَ الْإِنْسَانَ مِنْ صَلْصَالٍ كَالْفَخَّارِ ○

“He created man from clay like the potter’s”

(Sura Rehman, Ayat 14)”

Therefore, it seems that there were two big steps as for as the creation of man was concerned. The first step was the creation from water. The second step was where by the first created thing, on admixing with clay was transformed into more advanced being. The same can also be applied to

other animals, because there are certain similarities between the structure of man and other animals. Digestive system, nervous system, circulatory system, excretory system and reproductive system are similar although dissimilar in other details.

Once the life had been created, Allah implemented the process of reproduction for the continuity of races of animals. The various stages of reproduction have been described in sura in following way.

ثُمَّ خَلَقْنَا النُّطْفَةَ عَلَقَةً فَخَلَقْنَا الْعَلَقَةَ مُضْغَةً فَخَلَقْنَا
الْمُضْغَةَ عِظْمًا فَكَسَوْنَا الْعِظْمَ لَحْمًا ○

“Then fashioned we the drop a clot, then fashioned we the clot a little lump, then fashioned we the little lump bones, then clothed the bones with flesh,

(Sura Almominoon, Ayat 14)

وَاللَّهُ خَلَقَ كُلَّ دَابَّةٍ مِنْ مَّاءٍ فَمِنْهُمْ مَنْ يَمْشِي عَلَى بَطْنِهِ
وَمِنْهُمْ مَنْ يَمْشِي عَلَى رِجْلَيْنِ وَمِنْهُمْ مَنْ يَمْشِي عَلَى
أَرْبَعٍ يَخْلُقُ اللَّهُ مَا يَشَاءُ إِنَّ اللَّهَ عَلَى كُلِّ شَيْءٍ قَدِيرٌ ○

“Allah hath created every animal from water some of them creep up on their bellies, other walk on two legs, and others on four. Allah creates what He pleases. He has power overall things”.

(Sura Nur, Ayat 45)

هَلْ أَتَى عَلَى الْإِنْسَانِ حِينٌ مِنَ الدَّهْرِ لَمْ يَكُنْ شَيْئاً مَذْكُوراً ○

“Hath there come upon man (every) any period of time in which he was a thing unremembered?”

(Sura Dahar Ayat 1)

A close study of above sermons reveals that all animals had common origin but they gradually underwent changes afterwards and became different from each other-i.e. some developed crawling, some started walking on two legs and some other had four. It seemed that animals of today are advanced forms of the past animals who achieved this form after passing through many changes.

2. Scientific Concepts

How did life originate on this earth? This may never be known for certain to science, because neither it is possible today to make observation of the then primitive events when the life actually originated nor there is any fossil record of the first formed softbodied organisms. In 1950 some scientist simulated the primitive earth conditions (approximately 4 billion years ago when life originated on earth) in the laboratory and started performing experiments on the basis of which scientists developed a few hypothesis, which seems near to what happened in the origin of life on earth.

Abiogenesis and Biogenesis

In ancient days, living things were believed to originate in two ways. First, a common observation that offsprings are produced by the parents of their own kind known as **biogenesis** and second, living things could be formed spontaneously from non-living things, which is called **abiogenesis**. Second hypothesis was formed due to lack of detailed information on the process of reproduction of various organisms because microscope and other aids had not been invented at that time which could help in detailed observations. It was generally believed that frog is produced from mud, mice from debris, insects from dewdrops and maggots from putrefied meat. Not only the common man but some scientist like Copernicus, Bacon, Galileo, Harvey, Descartes had also this same belief.

From 16th to 18th century, some scientist performed a few experiments and apparently found that some animals were produced from non-living things, which supported abiogenesis. Later on scientists carried out more careful experiments and in 1668, an Italian scientists F. Redi disproved abiogenesis experimentally.

Redi's Experiments

He took two sets of four bottles each. In first set, he placed dead snake in one bottle, a few dead fish in the second bottle, third bottle contained dead Eels and in fourth a piece of meat. (Fig 1.6).

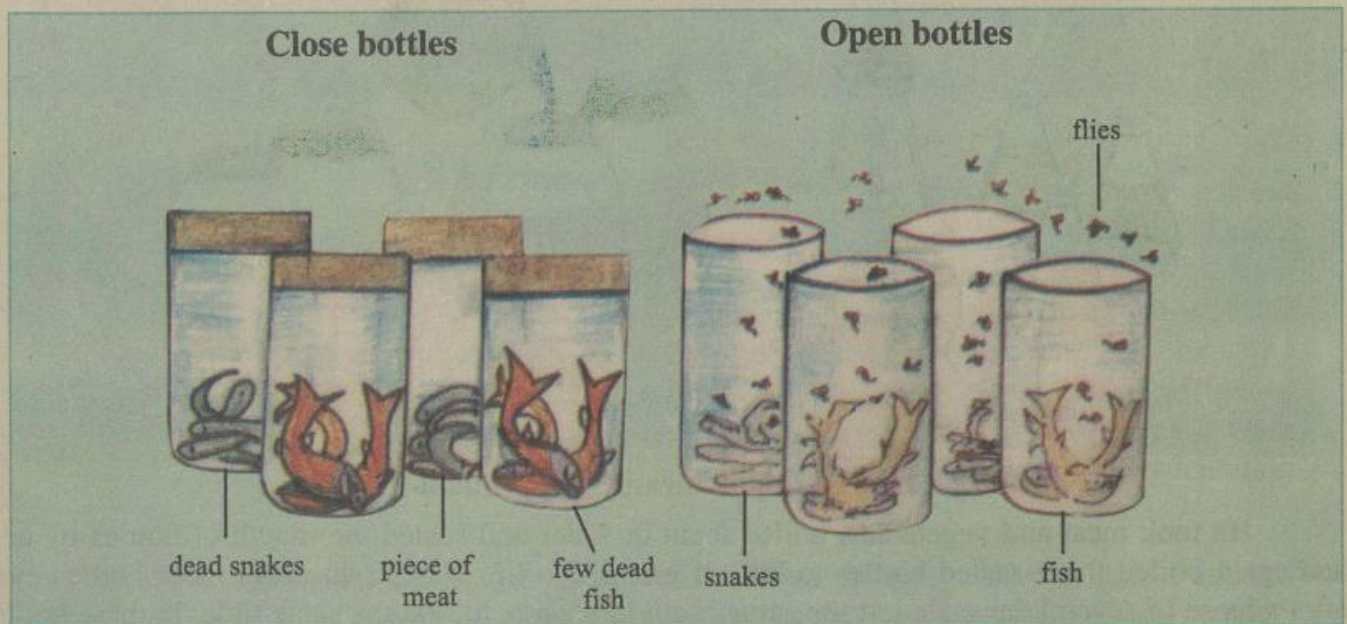


Fig. 1.6 Redi's experiment on biogenesis

All bottles of this set were left open. The contents of these bottles were visited by flies. In the second set of bottles he placed same dead animals in all four bottles respectively but covered the mouth of the bottles of this set so that flies could not enter the bottles.

After few days, maggots were produced in the first four open bottles whereas no maggots were produced in covered bottles. From this it was concluded that maggots were not produced spontaneously instead flies were responsible for these maggots. The maggots were the larvae produced from the eggs of the visiting flies.

Needham's Experiment

In 1748, an English scientist Needham, boiled meat in water, poured this gravy in bottles and closed their mouth with cork. After a few days many micro-organisms were produced in these covered bottles. This once again excited the believers of abiogenesis i.e. life from non-life (Fig. 1.7).

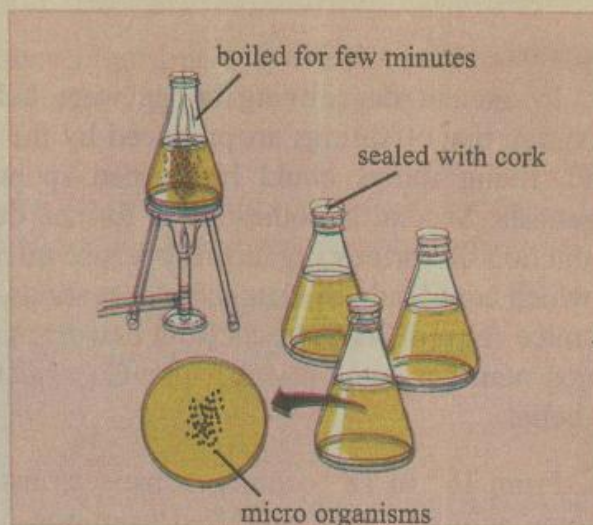


Fig. 1.7 Needham's experiment

Spallanzani's Experiment

An Italian scientist Spallanzani (1767) criticized the experiment of Needham. He stated that cork was a porous structure and was not airtight. Therefore, air entered in the bottle and hence living organisms were produced.



Fig. 1.8 Spallanzani's experiment

He took meat and vegetables, boiled them in water and sealed the mouth of bottles by heat and again boiled these sealed bottles to kill all germs. No life was produced in these bottles even after a lapse of several days. He left the same broth in open bottles at the same time. In these bottles the living organisms were produced (Fig. 1.8). This supported biogenesis. But the supporters of abiogenesis criticized him and said that air, which, according to them, was removed by heating of bottles by Spallanzani was necessary for living things, therefore, no life was produced in sealed bottles. In 1774, oxygen was discovered as an important component of air for respiration and burning. Abiogenesis supporters said that Spallanzani had eliminated oxygen where by no life could be produce in his experiment.

The argument on the issue of biogenesis and abiogenesis continued up to the middle of nineteenth century, till Louis Pasteur, a renowned French Scientist proved, after simple but very careful experiments, that abiogenesis could not occur in the present environment of earth. He proved finally that living organisms could only be produced from their parents (living organisms).

Pasteur's Experiment

In 1864, Pasteur performed his experiment in front of the commission formed of noted biologists, to resolve this issue. He took flasks which had long curved S-shaped necks (figure 1.9). He added fermentable infusion (yeast + sugar + water) in bottles and left their mouth open.

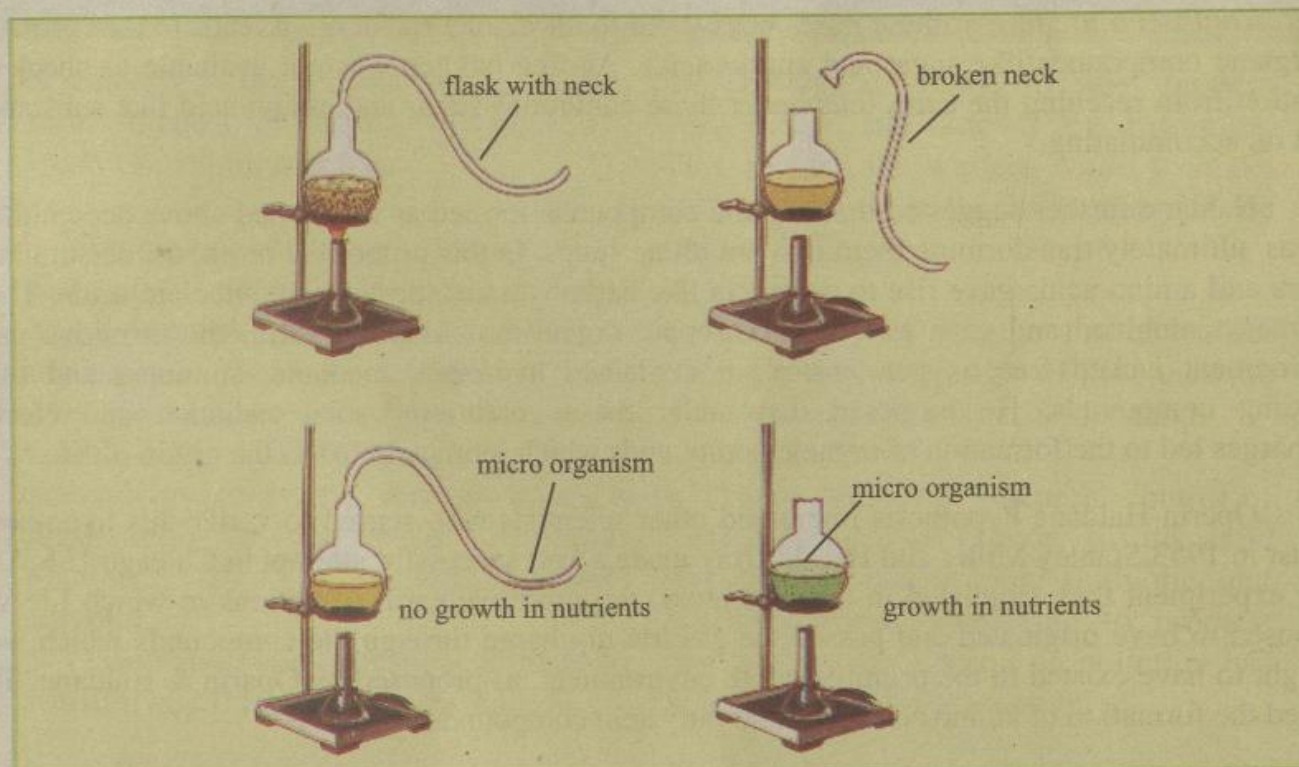


Fig.1.9 Pasture's experiment.

The yeast infusions were boiled in the flasks and let steam issued out of the neck of each flask. Then flasks were allowed to cool. No life was produced even after the lapse of several days; because micro-organisms entering along with incoming air got stuck up in on the curved walls of the glass necks. To prove this he broke up the curved necks, so that now contaminated air could reach directly to the infusion. He now observed that microorganisms were produced within 48 hours. This proved that if care was taken and no micro-organisms (their eggs or spores) were allowed to reach the infusion, no life could be produced because there is no spontaneous generation of life from nonlife.

For next sixty years no experiments were performed on the origin of life after Pasteur's experiments, till in 1920, when a Russian Biochemist Alexander Oparin and british biologists J.B.S Haldane suggested separately that life on earth was not evolved instantaneously and miraculously but it originated after a long and gradual molecular evolution which was spread over a very long time in the past.

Chemical and Organic evolution on Earth

According to Oparin and Haldane the origin of first life had been initiated from the time when the solar system came into existence (sun with its nine planets). Earth, like sun was made up of light and heavy elements. Heavy elements like Iron, nickel etc. were present in the nucleus of earth while the light elements and compounds like hydrogen, methane, nitrogen, carbon, ammonia, nitrogen oxide etc. in the form of vapors existed on the surface of the earth. These light elements and compounds were responsible for first life on earth.

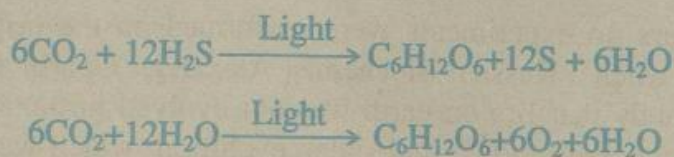
Earth had high temperature and radiation and had frequent and abundant electric discharges. Those were the conditions when first life originated. Oparin and Haldane suggested that simple inorganic molecules slowly and gradually combined to produce complex organic molecules, from which the simplest form of life (bacteria) came into existence. This process took a long time.

Haldane proposed that primitive earth's atmosphere only had carbondioxide, ammonia and water vapors. If a mixture of these gases is exposed to ultraviolet radiation, it leads to the formation of organic compounds like sugar and amino acids. As free oxygen was not available to check the radiation from reaching the earth thus under these conditions sugar and amino acid like substances went on accumulating.

Haldane further suggested that organic compounds formed as mentioned above accumulated in seas ultimately transforming them into hot dilute soups. In this primordial broth, the accumulated sugars and amino acids gave rise to polymers like carbohydrates, proteins and nucleic acids. These polymers combined and gave rise to microscopic organisms. As per Oparin, the primitive earth environment lacked free oxygen, instead it contained hydrogen, methane, ammonia and other reducing compounds. He proposed that under these conditions, solar radiation and electric discharges led to the formation of organic compounds which ultimately led to the origin of life.

Oparin-Haldane hypothesis impressed other scientists who started to verify this hypothesis. At last in 1953, Stanley Miller and Harold Urey made a first successful attempt in Chicago, U.S.A. In their experiment they simulated in the laboratory, the primitive earth conditions in which life was supposed to have originated and passed the electric discharge through the compounds which were thought to have existed in the primitive earth environment, as proposed by Oparin & Haldane. This caused the formation of amino acid, urea and fatty acid compounds.

The fossil evidence indicates that the earliest forms of organism lived about 3.8 billion years ago. From this it is speculated that origin of life started about 4 billion years ago. The earliest life form was bacteria like, they were primary heterotrophs.- who used to get their food from the same environment and were probably anaerobes (capable to live in absence of oxygen). The depletion of pre-existed food from the environment led to the evolution of organisms capable of making their own food i.e., autotrophs. They succeeded in establishing themselves and reproduced in that environment. These early autotrophs did not use water in the photosynthesis, instead they used hydrogen sulphide for making carbohydrates from carbondioxide, because hydrolysis of water required more energy, however when hydrogen sulphide got depleted in the environment then they started using water.



In this way photosynthesis led to the accumulation of oxygen in atmosphere. When oxygen concentration reached approximately to 1% of the atmospheric air, ozone formation and accumulation started which gradually, with increase in oxygen concentration lead to the formation of existing ozone layer in the atmosphere. This layer inhibited the penetration of ultraviolet radiation to earth surface. Accumulation of oxygen brought many changes in the environment. Nonaerobes (organism which require oxygen) were produced. These were small organisms, consisting of one cell and were prokaryotes, that is, they lacked nucleus but had DNA.

After this, large number of aerobic organisms evolved, which used oxygen. Thus the existence of the photosynthetic organisms became a necessity for the life of other organisms on this earth. It took about 1.5 billion years in evolving eukaryotes and existing multi-cellular organisms from the prokaryotes.

KEY POINTS

1. Biology is the scientific study of life, the biological study to the modern basic themes of biology includes the information and knowledge resources. study of evolution of life. This enabled the western world to make further progress in the 20th century in the field of biology.
2. The biological method of study is just like other natural sciences. Biologist usually gathers observation and facts, on the basis of these observations, develop hypothesis, make deductions that can be tested by experimentation, draw conclusions and give answer to these observation on the basis of results obtained. This is called **scientific method**.
3. Observation and experiments made by Muslim and European experts introduced the biological study to the modern information and knowledge resources. This enabled the western world to make further progress in the 20th century in the field of biology.
4. The study of Islamic and scientific concepts about the origin of life made the philosophy of life easy to understand.
5. Due to biological research, control of food shortage, prevention of diseases, discovery of vaccines and antibiotic, and use of genetic engineering to produce new species and control on pollution has beneficial effect on human life.

QUESTIONS

1. Fill in the blanks

- (i.) The break down of food in the cells is called _____ process.
- (ii.) Process of reproduction enables _____ to survive otherwise that individual is eliminated.
- (iii.) A scientist named Ronald Ross, proved after many experiments that _____ mosquito is responsible for spreading malaria in human.
- (iv.) The progressive changes in organisms are called _____.
- (v.) Most of the scientist believe that origin of life started from _____.
- (vi.) Malarial patient have _____ in their blood.

2. Write whether the statement is

'true' or false' and write the correct statement if it is false.

- (i.) "Al Shafa" is written by Bu Ali Sina
- (ii.) "Hayat-ul-Haywan" is written by Abdul Malik Asmai.
- (iii.) Study of microorganisms is called Biology.
- (iv.) Ibn-ul-Haitham discovered blood circulation in lungs
- (v.) Bu-Ali-Sina was one of the founder of medicines

3. For the following questions four options have been given, encircle the correct answer.

- (i.) Metabolism is called:
 - (a) An increase in the number of cells
 - (b) The sum of all the chemical activities

of an organism.

(c) The characteristics of animals only.

(d) Changes in the environment of an organism.

(ii) A testable statement is (a/an)

(a) problem (b) experiment

(c) hypothesis (d) prediction

(iii) The role of vector in a malaria disease is played by

(a) bird (b) mosquito

(c) blood (d) human being

(iv) A testable statement is (a/an)

(a) theory (b) hypothesis

(c) principle (d) observation

(v) A farmer was worried to notice that his potted plants kept under tree shade grew better than those exposed to bright sunlight. A biologist would consider the above fact as a/an.

(a) problem (b) hypotheses

(c) experiment (d) observation

(vi) One species of plants, grows best in place (a) as compared to place (b), to know the reasons biologist would name this as (a/an)

(a) Problem (b) Experiment

(c) Hypothesis (d) Prediction

4. Match the terms of column A with the relevant statements of column B.

Column A	Column B
Morphology	Interaction between living things and their environment
Physiology	Use of biological technique for the welfare of mankind
Genetics	Study of external structure of living things.
Biotechnology	Study of transmission of biological characters
Ecology	Study of function of different parts of organism.

5. Give short answer to the following questions.

i. How is the metabolism related to growth?

ii. What is the relationship between metabolism and response?

iii. In what ways are growth and reproduction similar? In what ways are they different?

iv. Which form of hypothesis is called a theory?

v. How does *plasmodium* enters the body of a mosquito?

vi. Does a candle flame show any of the characteristics of life?

6. Explain the contributions of different Muslim scientists in the field of biology.

7. Explain the scientific method in biology to resolve the malaria problems.

8. Do you agree with this statement that biology has helped us to improve our life. Give two reasons why?

9. A motor car moves, takes in oxygen and gives out carbon dioxide, consumes fuel but nevertheless is not a living creature. In what ways does it not "qualify" as a living organisms.

10. Develop a deduction from the following hypothesis and test it by experiments.

i. A mold found in garden does not help in making antibiotic medicines.

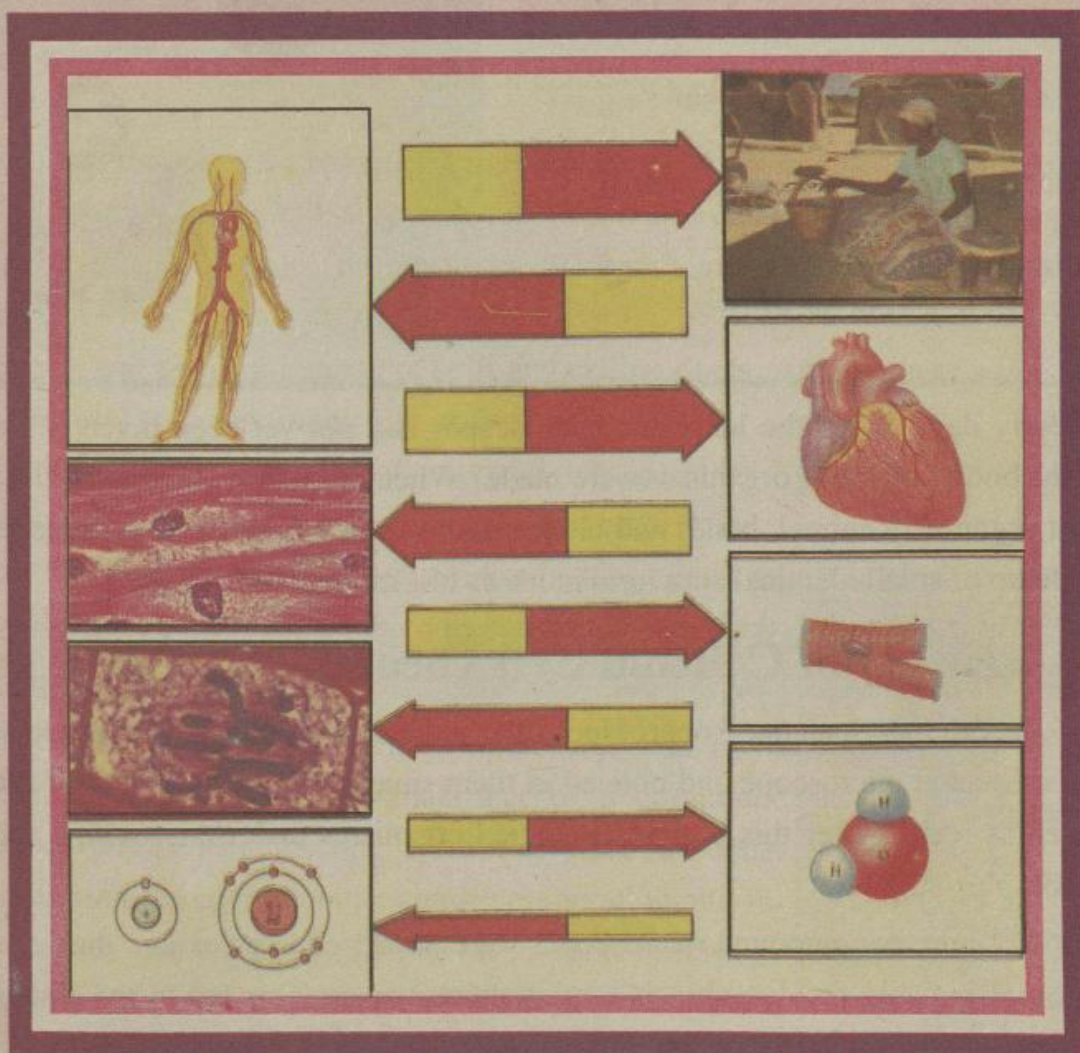
ii. The rate of growth of seeds is affected by temperature.

11. Explain the contributions of European scientists in the field of biology.

12. Explain the concepts given for the origin of life on earth.

Section 2

(Organization of Life)



ORGANIZATION OF LIFE

In this chapter you will learn:

- The discovery of cell and cell theory
- Light microscopy and electron microscopy.
- Structure and function of cell and its organelles.
- Comparison of prokaryotic and eukaryotic cells.
- Mitosis, meiosis, their different phases and importance.
- Three levels of organization in organisms, tissue, organ and system.
- Different types of plant and animal tissues.
- Cell as a unicellular organism e.g. *Amoeba*.
- Multicellular plant, external and internal structure of mustard plant.
- Multicellular animal, structure and function of different systems of frog.



In the early days, when the lenses or microscopes had not yet been invented, man was not aware of how the bodies of living organisms were made? Whether they possess an undivided body, in which different organs (in animal, bones and blood vessels etc) are arranged systematically or their bodies are made up of small identical structural units, as bricks form a building.

2.1 The Discovery of Cell and Cell Theory

In 1665, an English Scientist Robert Hook first studied thin slices of cork and leaves under his self made compound microscope and noticed in them small box like chambers of the small size, which he named as 'cell'. After this biologists studied organisms under microscope and found that cells were of complex structure.

In early 19th century, compound microscopes were improved to an extent that now under the microscope biologists could resolve objects a micronmeter apart. This led to the discovery of new things, which provided basic information for cell theory. Robert Brown (1831-1833) discovered nucleus in the cell. In 1838, a German botanist Mathias Schleiden claimed that all plants were made

up of cells. This was supported by Theodre Schwann in 1839, ascertaining that animals were also made up of cells which are similar to plant cells. Thus Schleiden and Schwann propounded cell theory i.e all organisms are made from cells.

In 1840, J.Purkinji used the term protoplasm for the materials found in the cell. A cell was considered a bag or box of thick, dense substance containing a nucleus. Progressive development in the staining and section cutting techniques of tissues and cells and further improvement in microscopes revealed that cell was not a simple mass of granular substance, instead, it contained subcellular bodies called organelles. These organelles performed specific functions for a living cell and that the cell was the basic unit of structure and function of living organisms.



Fig. 2.1 Cells of cork

It is estimated that human body is made up of nearly 60 trillion cells and from *amoeba*, unicellular alga to giant whales and red wood trees, are made up of cells which are basic unit of structure. All animals and plants are thus made of cells and cell products.

With the invention of electron microscope and better versions of compound microscopes and the usage of biochemical and molecular analysis techniques, cells are now being understood more comprehensively. The cell theory presented by Schleiden and Schwann has now the following salient features.

- (i) All animals and plants are made of cells and cell products. Among these some organisms are unicellular and some are multicellular.
- (ii) Cells are structural and functional units of living organism.
- (iii) New cells come from the pre-existing cells by cell division.

To study a cell, light microscopes are used (light microscope has already been discussed in chapter I). More details are revealed by electron microscopy.

2.1.1 Electron Microscope

This is the most advanced form of microscope, having a resolving power 250 times or more than that of a compound microscope. In an electron microscope a beam of electrons under high voltage is passed through the object under observation and for making a photograph, the image is reflected on to a screen through an electromagnetic lens. The wavelength of electron beam used is $1/100000$ or (10^{-5}) of white light. Electron microscope has capacity to magnify an object up to 2,50,000 times of its original size.

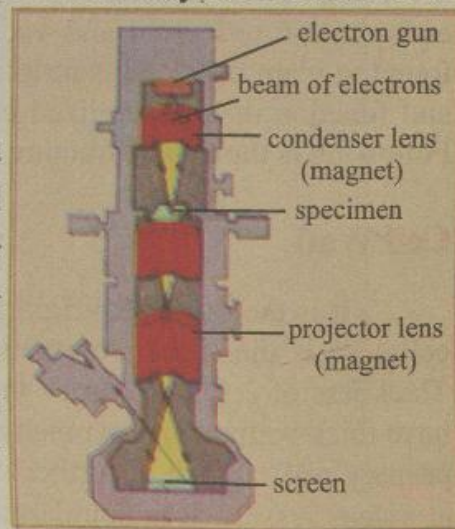


Fig. 2.2 Principle of electron microscope

Comparison of light and electron microscope

	Characteristics	Electron Microscope	Light Microscope
(1)	Radiation source	Electron	Light
(2)	Wave length	0.005nm	400-700nm
(3)	Maximum resolution in Practice	0.5nm	200nm
(4)	Maximum useful magnification	X250,000 on Screen as image or photograph	x1500 with eye
(5)	Lenses	Electromagnets (condenser and objective)	Lens

2.1.2 Structure of Cell

Cells are basically of two types prokaryotic and eukaryotic. Prokaryotic cells have no membrane bounded nucleus and subcellular organelles while eukaryotic cells have a membrane bounded nucleus and organelles.

A eukaryotic cell may be compared to a factory where different machines and people have different jobs, all working together for achieving one goal. Efficiency is improved by “division of labour”, the sharing out of jobs. In the cell different organelles have their own specific roles, involving their specialized structure and chemistry. Nucleus, mitochondria, Golgi bodies, endoplasmic reticulum and vacuoles are found both in plant and animal cells, while plastids are found in plant cells and centrioles occur only in animal cells. In order to know the detailed structure and function of a generalized cell, it is studied with the help of light and an electron microscope. Following is the detail structure of a generalized eukaryotic cell and its organelles:-

Cell Wall

It is the outer semirigid and non-living boundary of a plant cell. In its chemical composition cellulose is the most prominent substance, where as, the cell wall of fungi is made up of chitin. Thickness of cell wall varies in different cells. e.g in plants, xylem, vessel elements and tracheids have thick walls while parenchyma cells have thin walls. The primary layer of the cell wall is called primary wall, which is further strengthened by an additional layer called secondary wall especially in xylem vessels. It is comparatively thicker than primary wall. Cell wall provides a definite shape, rigidity, protection and support to the cell.

The study with electron microscope reveals that in primary and secondary cell walls, the cellulose fibers are present in a criss cross manner, which provide rigidity.



Fig. 2.3 Cell wall

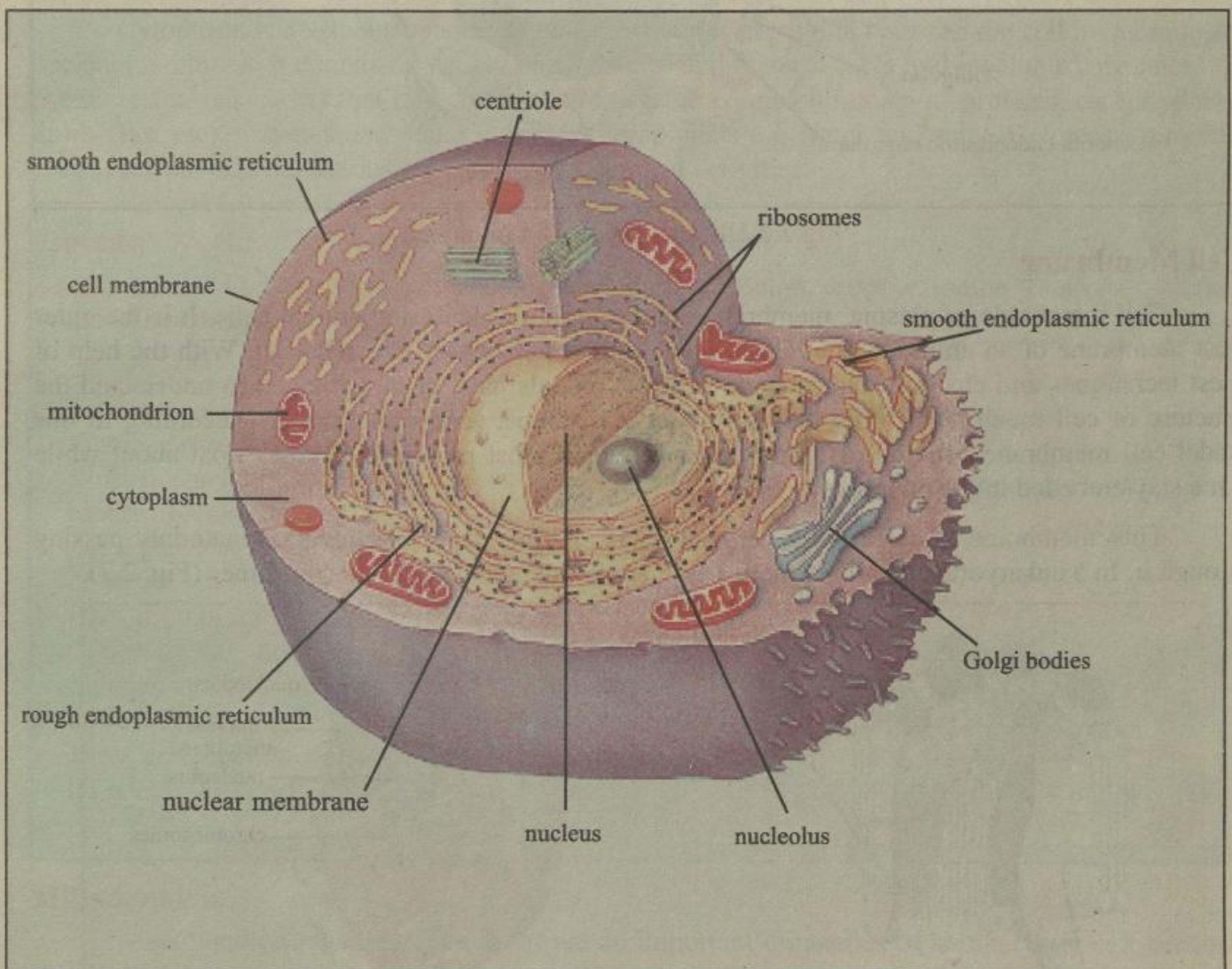


Fig 2.4 Ultra structure of an animal cell.

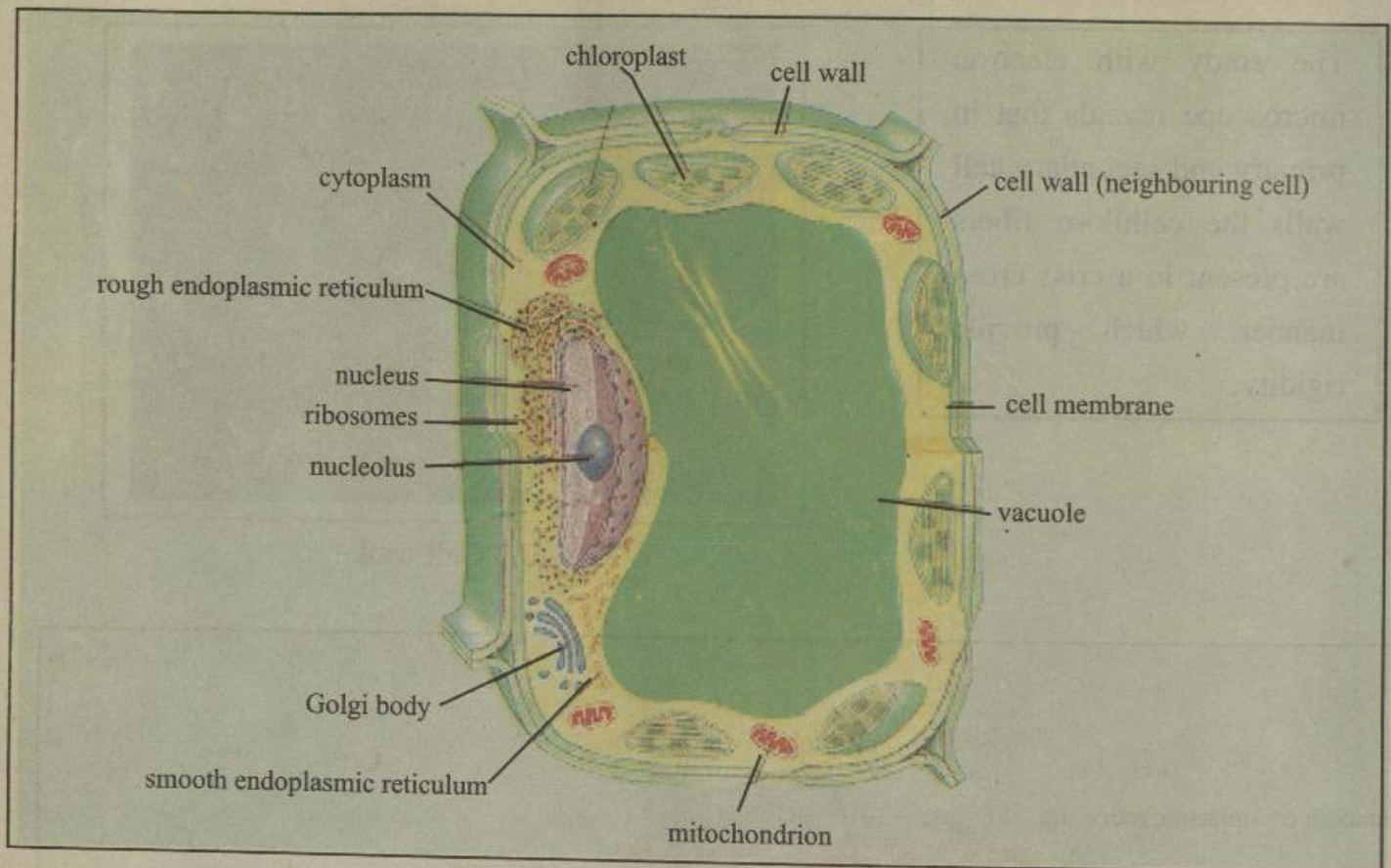


Fig 2.5 Ultra structure of a plant cell

Cell Membrane

Cell membrane or plasma membrane is present in all plants and animal cells. It is the outer most membrane of an animal cell while in plant cell it lies next to the cell wall. With the help of latest techniques and electron microscopy, different models have been presented to understand the structure of cell membrane. Fluid mosaic model is the most acceptable model. According to this model cell membrane consists of lipid bilayer in which most protein molecules float about while some stay embedded in the membrane.

This membrane is selectively permeable. It controls the movement of materials passing through it. In a eukaryotic cell all organelles are membrane bounded except ribosomes (Fig. 2.7).

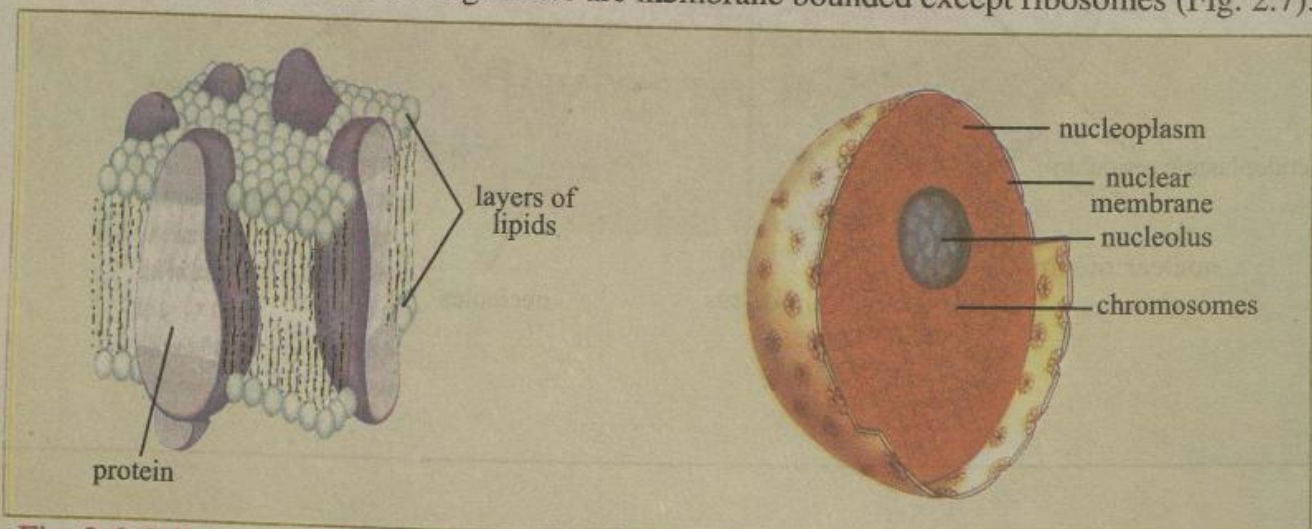


Fig. 2.6 Cell membrane (Fluid mosaic model)

Fig. 2.7 Nucleus

Nucleus

The most important and visible part of a cell is nucleus. It is present in the center of the animal cell but due to the presence of large central vacuole it is pushed on one side in the plant cell. Its envelope is called the nuclear membrane, which is double membraned and porous. In the nucleus there is a granular matrix called nucleoplasm, in which one or two nucleoli and chromosomes are present. Chromosomes are more visible in dividing cell while in the non-dividing cell they are like a network of fine threads. The chromosome number is always specific for any species e.g, the number of chromosomes in man's cell is 46, in radish 18 and in onion 16. In fact, chromosomes occur in pairs in diploid cells, two similar chromosomes are called homologous chromosomes. e.g, in human cell there are 2 sets of 23 chromosomes each. Chromosomes are formed of protein and DNA. Protein provides structural support to DNA for making chromosomes. DNA controls all the functions and it is hereditary material also that is why the nucleus is called the brain of the cell. In the nucleolus ribosomal RNA are formed, which help in making ribosomes.

Cytoplasm

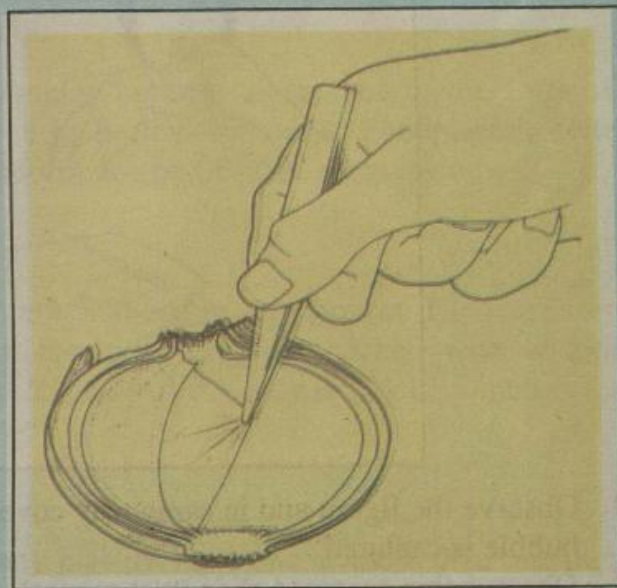
Cytoplasm is a viscous opaque substance, which is present in between the cell membrane and nuclear membrane. It contains a variety of organelles and many soluble and insoluble substances. Its chemical analysis shows that it is composed of organic compounds such as proteins, carbohydrates, lipids (fats etc) enzymes and some inorganic compounds e.g water and salts. Cytoplasm provides chemicals, site and conditions for various biochemical activities.

Practical Work: To observe the epidermal cells of onion

Apparatus: Light microscope, slide, cover slip, blade, onion, dropper, iodine solution or solution of methylene blue.

Method:

1. Take an onion and peel off its scale leaves and separate a fleshy leaf base.
2. With the help of a pair of forceps remove the epidermis from the leaf.
3. Cut a piece of it and put it on the slide in a drop of water.
4. Put a drop of iodine or methylene blue on it.
5. Cover it with a cover slip, avoiding any air bubbles under it.
6. Observe this slide under microscope.
7. Draw and label the diagram of the cell as you see it under microscopes.



Mitochondria

Mitochondria(single mitochondrion) are an important organelles of a eukaryotic cell,because they provide energy to the cell and are thus known as the 'power house of the cell'. They are oval or rod like in shape, bounded by double membrane. Outer membrane is smooth while inner membrane forms infoldings in the inner chamber or mitochondrial matrix. These infoldings are called cristae,

which bear small rounded bodies called elementary particles ranging up to one million in number. Which are involved in oxidative phosphorylation. They contain a series of respiratory enzymes.

In different animal cells, number of mitochondria differ. The cells which are more active e.g. liver cells have more than one thousand mitochondria while ear lobes have very small number.

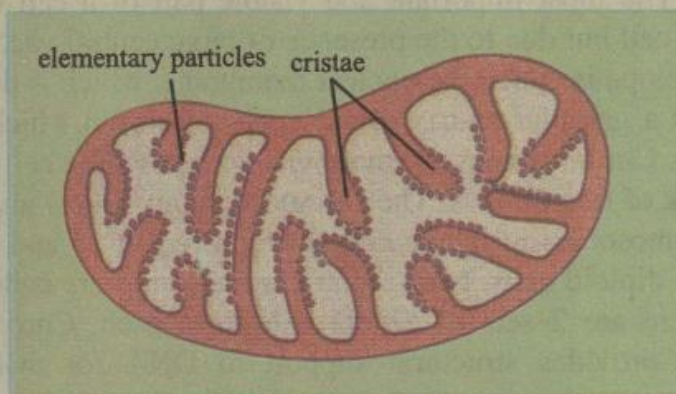


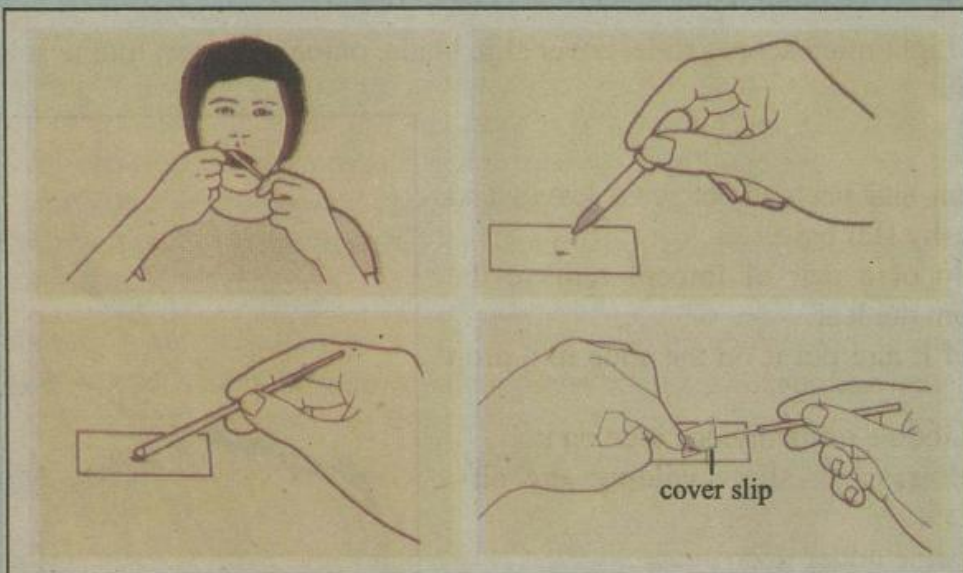
Fig.2.8 Mitochondrion

Practical work: To observe the cell membrane, cytoplasm and nucleus in the animal cell (cheek cell).

Apparatus: Microscope, cover slip, slide, tooth pick, dropper, iodine solution.

Method:

1. Take a clean slide and put a drop of iodine solution on it.
2. Take a tooth pick and gently scrub the inside of your cheek, a small amount of material would come on the tooth pick (always use clean tooth pick).
3. Mix this material in the drop of iodine.



4. Observe the figure and in same way cover it with cover slip at an angle in such a way that no air bubble is captured.
5. Observe this prepared slide (wet mount) under (low and high magnification) microscope.
6. Draw and label the diagram, compare your diagram with fig.2.4 and list which organelles you can see.

Golgi Bodies

Golgi bodies have been named after a scientist called "Golgi", who first discovered them. This consists of a set of smooth, flattened membranous sacs called cisternae that are stacked over

each other. In some cells Golgi bodies may occur as a network or a meshwork or in filamentous form. Their function is to store the secretions, convert them into finished products and pack them at their margins into small rounded sacs called Golgi vesicles, which transport secretions outside the cell.

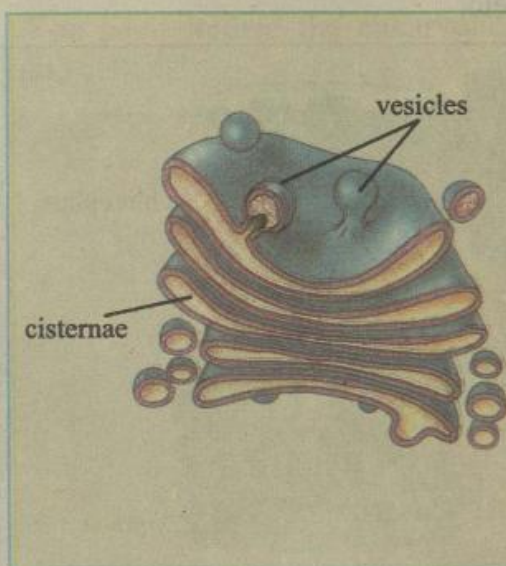


Fig.2.9 Golgi bodies

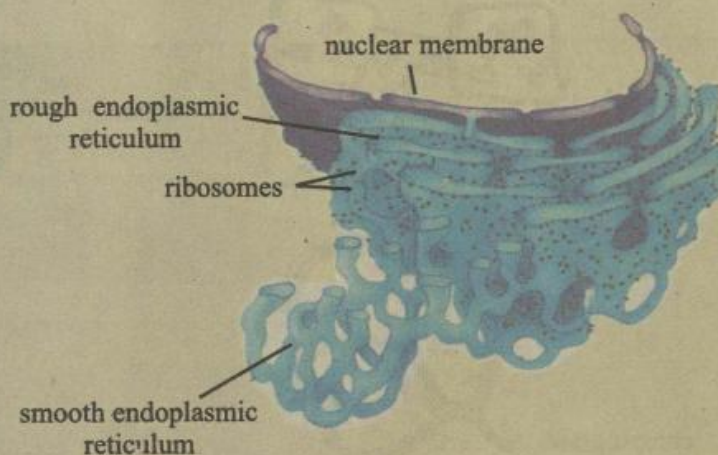


Fig.2.10 Endoplasmic reticulum

Endoplasmic Reticulum

It is the net work of channels and cisternae extending throughout the cytoplasm from nuclear membrane to the plasma membrane. These are of two types.

- 1. Smooth endoplasmic reticulum:** It is non granular because ribosomes are not attached on it. These play an important role in lipids formation.
- 2. Rough endoplasmic reticulum:** It is granular because ribosomes in the form of small granules are attached on it, which are involved in protein synthesis. Endoplasmic reticulum plays an important role in transport of materials from one part of the cell to the other.

Ribosomes

These are tiny granular structures which are not bounded by membranes. These are formed in the nucleolus and are either freely dispersed in the cytoplasm or attached with endoplasmic reticulum. These are involved in the synthesis of proteins. It is the only organelle which is found in prokaryotic cell.

Plastids

These are present only in the plant cell. Many plastids have one or more than one pigments. Plastids are of three types, the most important of which are chloroplasts. These are present in the green parts of the plant particularly in leaves. Chlorophyll is present in them, which helps in photosynthesis. Its ultra structure shows that it is bounded by a double membrane. Inside the chloroplast a semi fluid matrix called stroma is present which is made of proteins and other chemicals. The inner membrane of the chloroplast gives rise to stacked membrane system that becomes suspended in the stroma. Each membrane stack is called granum (plural grana). Membranes of the grana are sites where photosynthesis takes place in the presence of sunlight

Second type of plastids is called chromoplasts. In plants colours, other than green, are due to these plastids. These are present in the petals of the flower and in the ripened fruit. Their function is to help the plant in pollination and dispersal of fruit. The third type of plastids is leucoplast, these are colorless triangular, tubular, or of any other shape. These are found in the plant parts where they store food particularly in roots and different types of tubers etc.

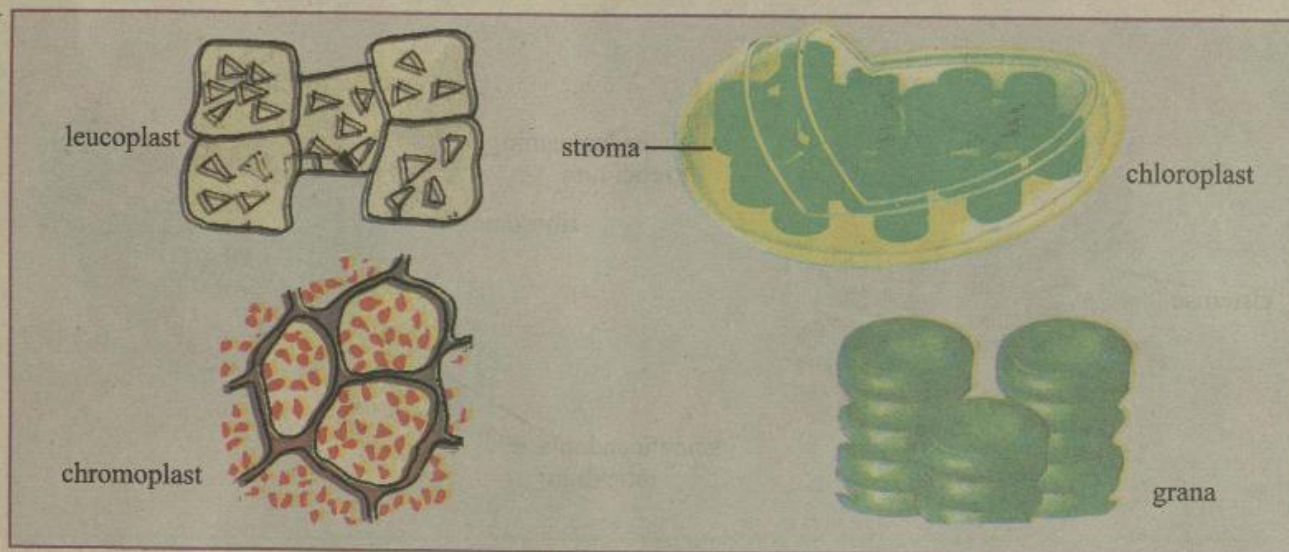


Fig.2.11 Plastids

Centriole

Two centrioles lie near the nucleus in an animal cell. These are hollow and cylindrical. Each centriole contains nine triplets of microtubules, their function is to help in spindle formation and cell division (spindle is composed of protein fibers which help the chromosomes to move). Centrioles are not present in higher plants. In some cells they help in the formation of cilia and flagella.

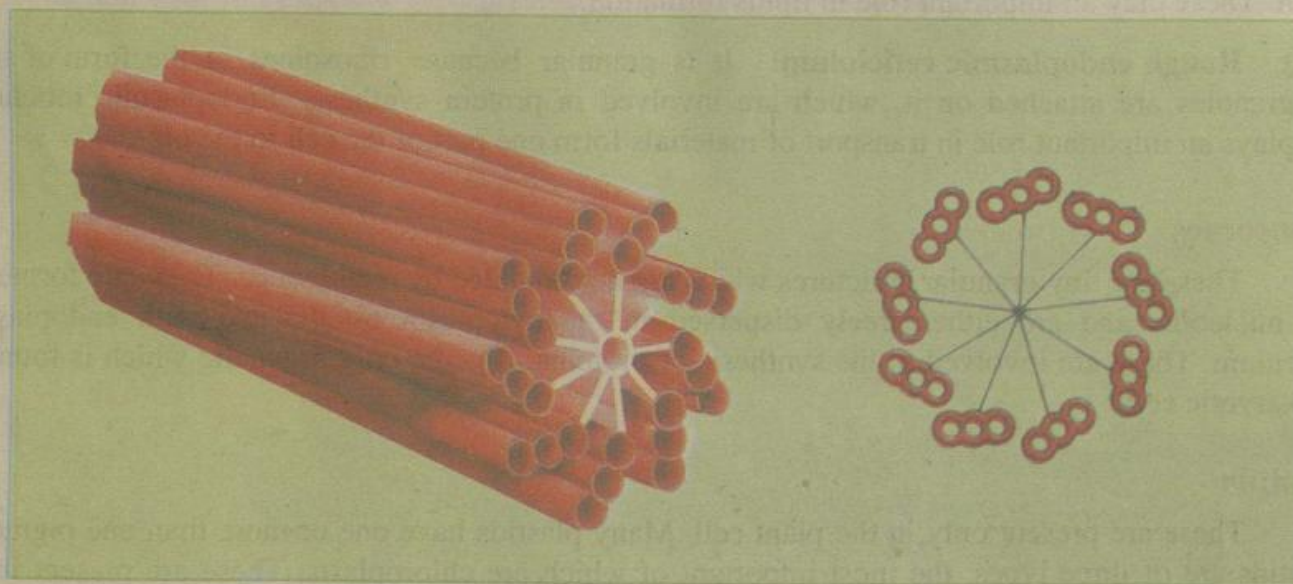


Fig. 2.12 Centriole

Vacuole

Vacuole is a fluid filled structure bounded by a single membrane. Animal cells contain relatively small vacuoles, which are usually more than one in number. However, in mature plant cells there is a large central vacuole filled with water and salts. In small organisms water and waste

materials are excreted through special vacuoles called contractile vacuoles and food is digested in food vacuoles.

Difference between Prokaryotic and Eukaryotic Cell

You have studied the eukaryotic cell. Let us see the difference between prokaryotic and eukaryotic cell.

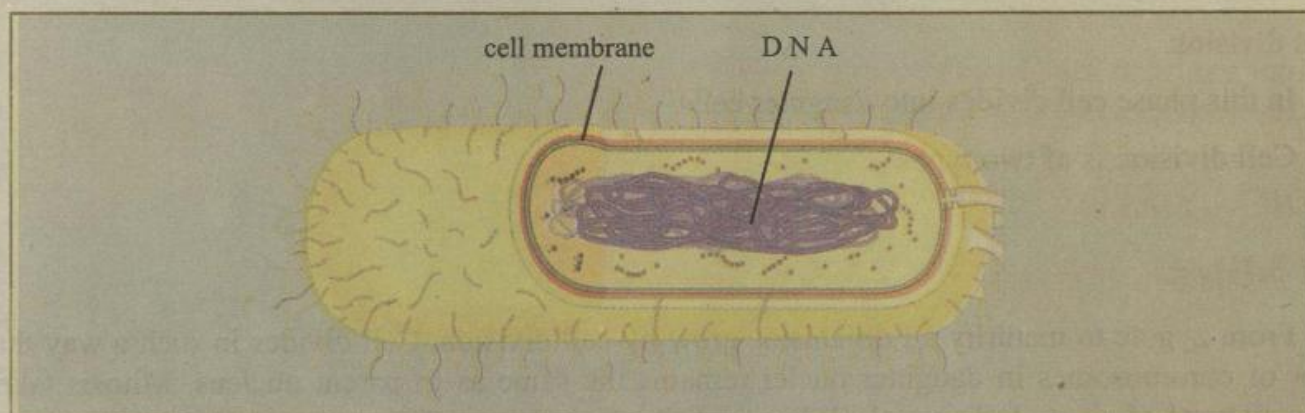


Fig. 2.13 Prokaryotic cell

Prokaryotic Cell

1. The organisms made of prokaryotic cell are called prokaryotes e.g. bacteria and cyanobacteria.
2. Chromosomes are present in the cytoplasm and no membrane bounded nucleus is present.
3. No membrane bounded cell organelles are present.
4. Ribosomes are of small size and freely scattered in cytoplasm.
5. Cell wall is composed of peptidoglycan or murein. Cellulose is absent.
6. These cells are simple, comparatively smaller in size (average diameter 0.5-10 nm).

Eukaryotic Cell

1. The organisms made of eukaryotic cell are called eukaryotes e.g animals, plants, fungi and protists.
2. Chromosomes are present in membrane bounded nucleus.
3. Membrane bounded organelles are present.
4. Ribosomes are of large size and are present on endoplasmic reticulum or free in cytoplasm.
5. Cell wall of plant cell is composed of cellulose while in fungi it is of chitin.
6. These cells are complex comparatively larger in size (average diameter 10-100 nm).

2.2 Cell Division

Survival of a specie depends on the continuity of its race, for which reproduction in one of the most important phenomenon. Reproduction involves cell division.

In unicellular organisms e.g Amoeba, a whole organism divides to produce two amoebae (offspring) whereas in multicellular organism, including humans, a single fertilized egg develops into an organism by repeated cell divisions. Even after the organism is fully grown, the process of cell division occurs continuously for repair and replacement of worn out or damaged cell. Continuous cell division in bone marrow, for providing new red blood cells is required to replace

the worn out R.B.C. All the changes during the formation of daughter cells from a parent cell is called cell cycle. Cell cycle is divided into two phases.

1. Interphase

This is the phase in which cell does not divide but many other changes occur, one of which is duplication of chromosomes.

2. Cell division

In this phase cell divides into daughter cells.

Cell division is of two types

- (i) Mitosis
- (ii) Meiosis

2.2.1 Mitosis

From zygote to maturity all organisms grow by cell division. Cell divides in such a way that number of chromosomes in daughter nuclei remains the same as in parent nucleus. Mitosis takes place in all parts of plants and animals. It has the following phases.

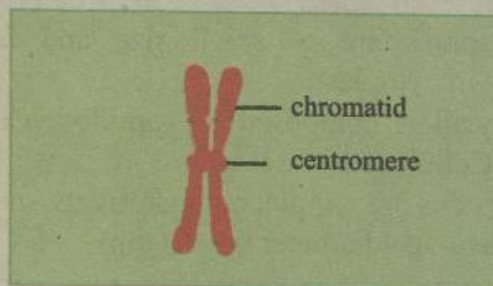
1. Prophase

In this phase the coiling of chromosomes starts and they become shorter and thicker, this is called condensation. Microtubules in the cytoplasm arrange to form a structure called spindle. In an animal cell, centrioles are also present on both the ends or poles of the spindle. From each centriole, fibers originate forming a star shaped aster. Spindle fibers, centrioles and aster collectively form a mitotic apparatus. Asters are absent in plant cells. While this process is occurring, nuclear membrane and nucleoli disappear and chromosomes scatter over the spindle fibers.

During this stage each chromosome consists of two thread like structures called chromatids attached to each other at centromere.

2. Metaphase

This is a phase where chromosomes arrange themselves on the equator of the spindle forming an equatorial plate and become more visible. The chromosomes are attached at their centromere to one spindle fiber from each pole.



Structure of chromosome

3. Anaphase

Spindle fibers shrink and becomes short. Centromere of each chromosome, divides and chromatids start separating. Each separated chromatid doubles itself and thus forming a chromosome of the daughter cell. These chromosomes start moving slowly towards the opposite poles. In this way one set of chromosomes moves towards one pole while other towards the other pole.

4. Telophase

This is the last phase of the cell division. Chromosomes reach their poles. They begin to uncoil and become less visible. The nucleoli reappear. Nuclear membrane begins to form resulting

into two new (daughter) nucleoli, each daughter nucleus has the same number of chromosomes as the parent cell.

Cytokinesis

The division of cytoplasm is called cytokinesis. It starts at the last stages of the nuclear division. In plant cells cytoplasm divides by the formation of a cell plate, which extends across the entire equatorial plane until the two daughter cells become separated.

In animals, cytoplasm divides by furrowing or inward pinching of cell membrane resulting into two daughter cells. The two daughter cells thus formed are identical to their parent cell in all respect.

Practical Work: To observe mitosis with the help of prepared slides.

- (1) Set the microscope
 - (2) Place the prepared slides of mitosis on microscope stage and observe them under low and high magnification.
- Which structures have you observed?
Draw and label the diagram of a chromosome.

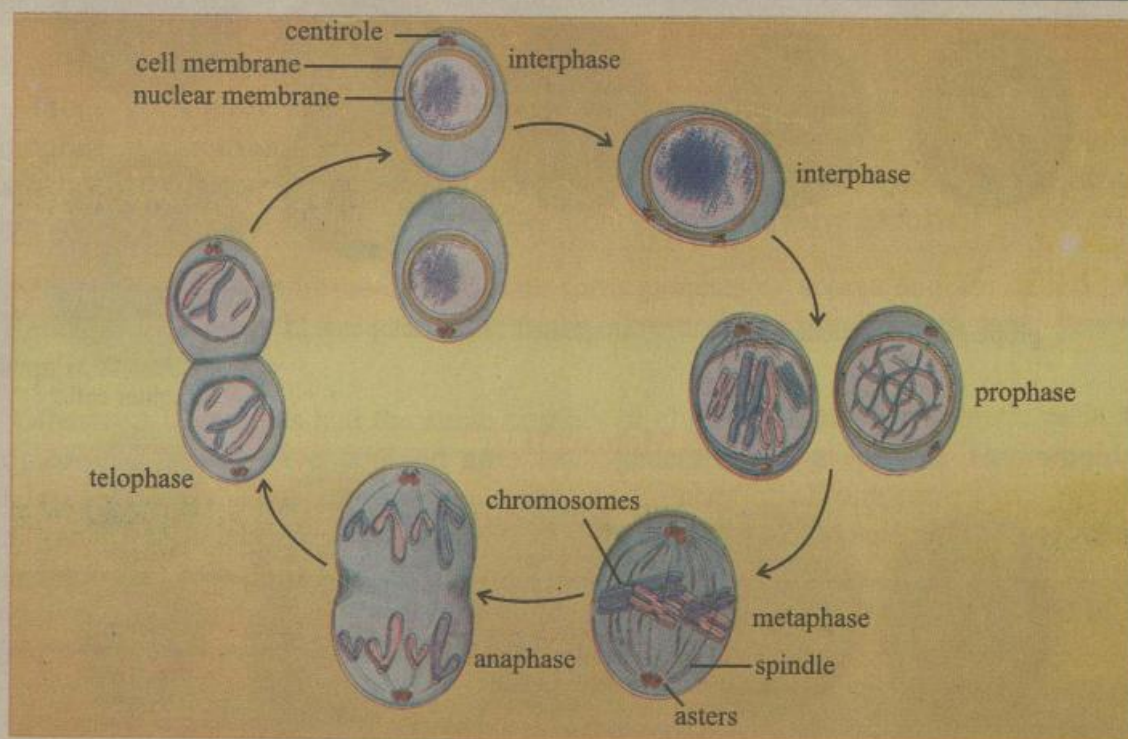


Fig. 2.14 Different phases of mitosis

2.2.2 Meiosis

This division takes place during sexual reproduction and occurs only in sex organs, i.e. in the sporangium in plants during spore formation and in animals in gonads during gamete formation. As a result of this division nucleus and cytoplasm divides twice and four cells are formed. They have half the number of chromosomes as compared to parent cell, that is a diploid ($2n$) cell forms four haploid cells. Meiosis can be divided in two divisions. (1) Meiosis I (2) Meiosis II

Meiosis I

It has the following stages.

Prophase I

It is a very lengthy and important phase. It can be divided into five more sub-phases, during which coiling of chromosomes continues. The important process of this phase is synapsis in which homologous chromosomes begin to pair length wise with each other. Each pair consists of two homologous chromosomes or four chromatids. After this crossing over takes place in which homologous chromosomes exchange their chromatids parts at certain places. At the end of this phase nuclear membrane and nucleoli disappear and chromosomes are scattered over the spindle fibers. In animal cell mitotic apparatus is formed as in mitosis.

Metaphase I

The centromeres of the homologous chromosomes arrange on the equator of the spindle. It is not the individual chromosomes but the homologous bivalents which arrange at equatorial plate of the spindle.

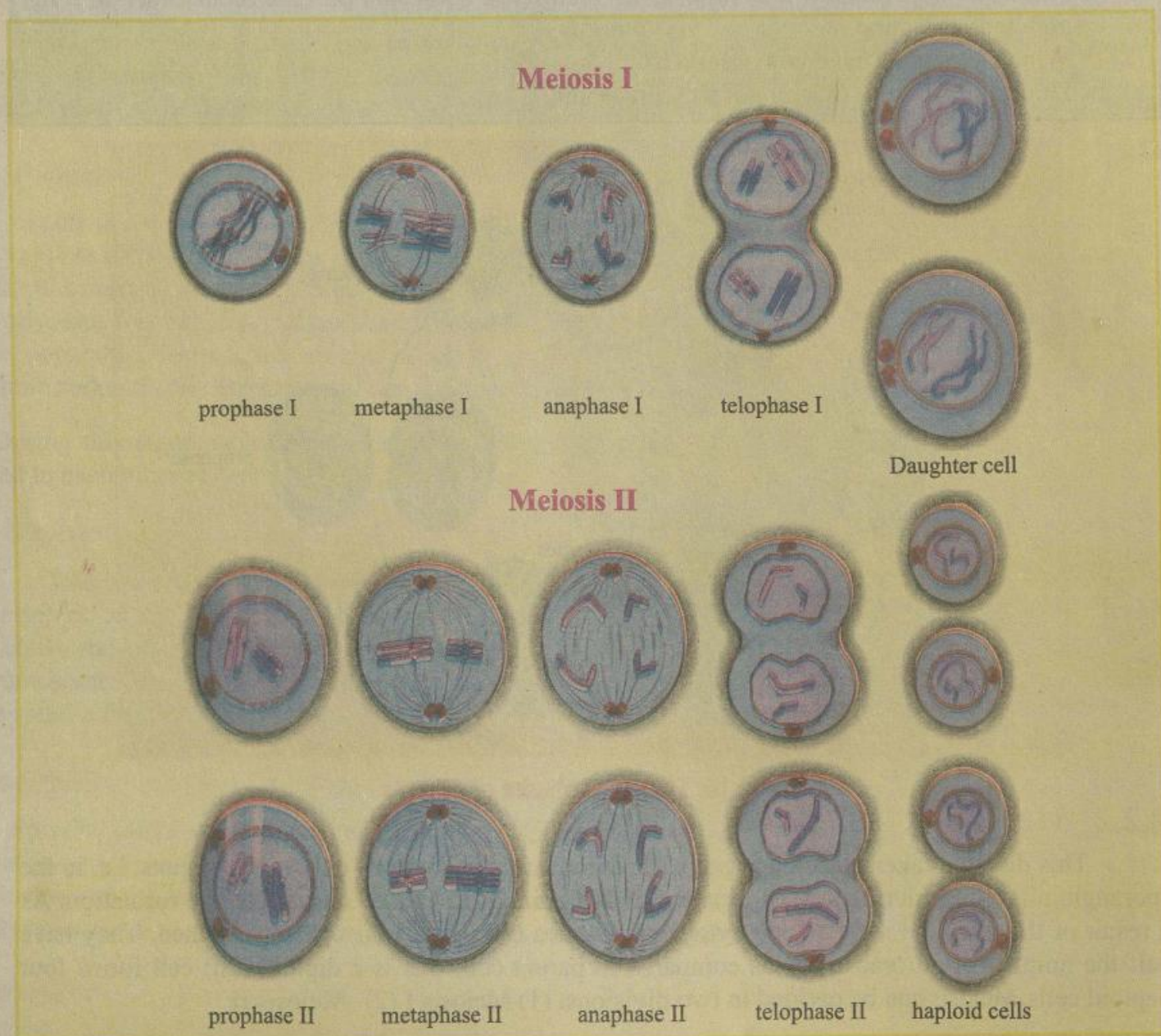


Fig. 2.15 Different phases of meiosis

Anaphase I

In this phase homologous chromosomes begin to separate, the spindle fibers contract. This phase is different from metaphase of mitosis because half the number of chromosomes move towards each pole and each chromosome still has two chromatids.

Telophase I

During this phase half the number of chromosomes reach at the opposite poles. Chromosomes again become elongated. Nuclear membrane and nucleoli are reformed. Two-daughter nuclei are formed. Each daughter nucleus has half the number of chromosomes and is haploid (n).

Meiosis II

This division is similar to mitosis. Haploid cells formed as a result of meiosis I pass through the stages of meiosis II, and at the end four haploid cells are formed which afterwards change into spores (in plants) or gametes (in animals).

Practical work

Observe the prepared slides of meiotic cell division under microscope, study the micrographs or charts. Draw different phases and differentiate between them.

Significance of Mitosis and Meiosis

Mitosis takes place in all somatic cells. Daughter cells formed as result of this division have same number of chromosomes as that of the parent cell. In this way all cells in the body of an organism have the same number of chromosomes. In an organism the process of growth and development, replacement of damaged and worn-out cells etc involve mitosis.

Meiosis takes place in the cells, which form gametes or spores and are called germ mother cells. Reduction division helps to maintain the chromosome number constant, generation after generation in a species.

Otherwise if gametes had the same number of chromosomes as in somatic cells, the number of chromosomes would have doubled after each generation in a species. This would have been against law of nature. Thus meiosis maintains the number of chromosomes in a species through haploid gametes, which on union (fertilization) restore the species number of chromosomes. Another important role played by meiosis is the reshuffling of genetic material which occur during crossing over of the homologous chromosomes during meiosis. This leads production of variation in the offspring, which forms the raw material for evolution.

2.3 Levels of Organization

In unicellular organisms, one cell is a complete organism, which is composed of different biochemical compounds. While in multicellular organism which are formed of millions of cells, have association of cells in their bodies to produce tissue. These tissues may be simple if they are composed of one type of cells only or they may be compound when they have different types of cells associated together to perform a certain function. Epithelial, connective, muscular and nerve tissue are example of animal tissue where as epidermal, ground and conducting tissue are examples of plant tissue. Different tissues form an organ e.g heart, kidney, liver of animals etc. In plants, root, stem and leaf are examples of organs. Different organs combine to form a system e.g circulatory system is formed from blood, heart, arteries, veins and capillaries. Digestive, muscular excretory

and reproductive systems are also such examples. In plants also, organs unite to form systems, for example root and shoot systems. Systems combine to form an organism.

2.4 Tissues

Tissues are defined as a group of cells associated together and performing a common function. Tissues are further divided into different types depending upon their function or morphology.

2.4.1 Plant Tissues

Plant tissues may be classified into two major groups.

1. Simple tissues
2. Compound tissues

1. Simple Tissues

They are composed of only one type of cells performing a common function. They are of the following types.

a. Meristematic or Embryonic Tissues

These are composed of cells, which have power of division. Each of these cells have dense cytoplasm, a large nucleus with small or no vacuoles. Cells are all alike, with no intercellular spaces, have thin walls and central nuclei. These tissues are found on the apex of root or shoot as apical meristem and divide and re-divide to add primary tissue for elongation of stem or root. Such a growth is called primary growth. Meristematic cells are also found on the lateral sides of roots and stems as lateral or intercalary meristem or cambium and their division adds secondary tissue increasing the thickness of stem and root. This is called secondary growth.



Fig. 2.16 Meristematic tissues in apical meristem

b. Permanent Tissues

The cells of these tissues lack the ability to divide. They largely originate from primary meristem. They are further divided into following groups.

Epidermal Tissues

They are found as the outermost protective covering of leaf, stem and root. Tissue cells are living thick walled flattened and closely packed with no intercellular spaces. Epidermal tissues of leaves and stem also have small guarded openings called stomata, for gaseous exchange.

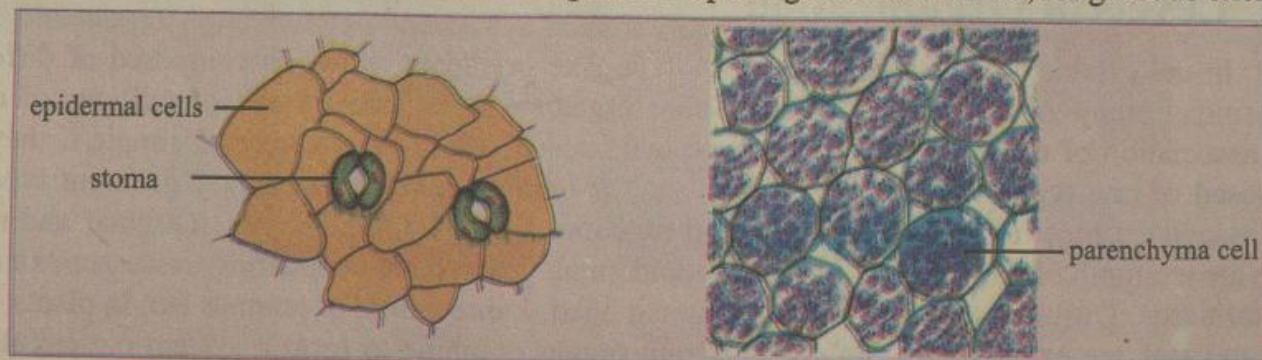


Fig. 2.17 (a) Epidermal tissues

(b) Ground tissue (parenchyma cells)

2. Ground Tissues

Herbaceous plants are predominantly composed of ground or parenchyma cells which have large sized living cells, having thin walls, and sometimes may develop the ability to divide. Their main functions are to make, and store food and water.

3. Supporting or Mechanical Tissues

These tissues provide strength and flexibility to the plant. They are of two types.

(i) Collenchyma tissues

(b) Sclerenchyma tissues

(i) Collenchyma tissues:- These are living cells with angular thickening of cellulose in the cell walls. They are more flexible/elastic as compared to Sclerenchyma cells. They are found in cortex of the midrib and petioles of leaves and in young herbaceous stems, where they provide strength to the plant parts.

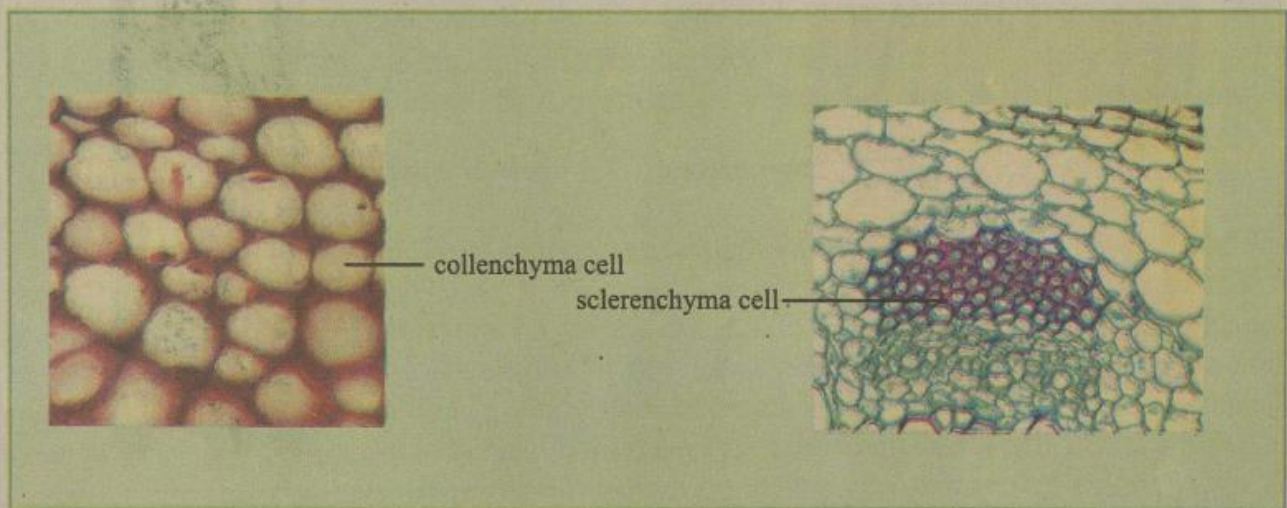


Fig. 2.18 (a) Collenchyma tissues

(b) Sclerenchyma tissues

(ii) Sclerenchyma tissues:- These are thick walled dead cells. Walls are heavily impregnated with lignin which provides hardness and strength to the cell. No protoplasm is present. Sclerenchyma cells are of two main types: **stone cell** having uniformly thick cell walls, found in testa of seeds, and elongated **fibrous cells** found in xylem and phloem for strength and transport of water.

(II) Compound Tissues

Tissues which are composed of different kinds of cells, performing a common function are called compound or complex tissues, xylem and phloem tissues found in vascular bundles are examples of compound tissues, which are vascular or conducting tissues.

Xylem Tissue

This vascular tissue provides strength and transports water in plants. Xylem or wood consists of xylem parenchyma and two types of thick walled dead cells. (1) Long vessel elements or cells with no end walls joined together to form long pipelines for unidirectional transport of water from roots to leaves. (2) Spindle shaped tracheids which in addition to being involved in the transport of water, provide strength to root, stem and branches.

Phloem Tissue

This vascular tissue helps in two directional conduction of food material i.e from leaves to roots and vice versa. It is made up of three types of cells.

- i. **Phloem parenchyma:** Which stores surplus food
- ii. **Sieve tube cells:** Their protoplasm has no nucleus and the end walls have small pores called sieve plates. Many sieve tube cells join to form long pipelines, which transport food.
- iii. **Companion Cells:** In some plants sieve tubes cells are accompanied with nucleated neighboring cell called companion cells, which regulate or control the movement of food through sieve tubes.

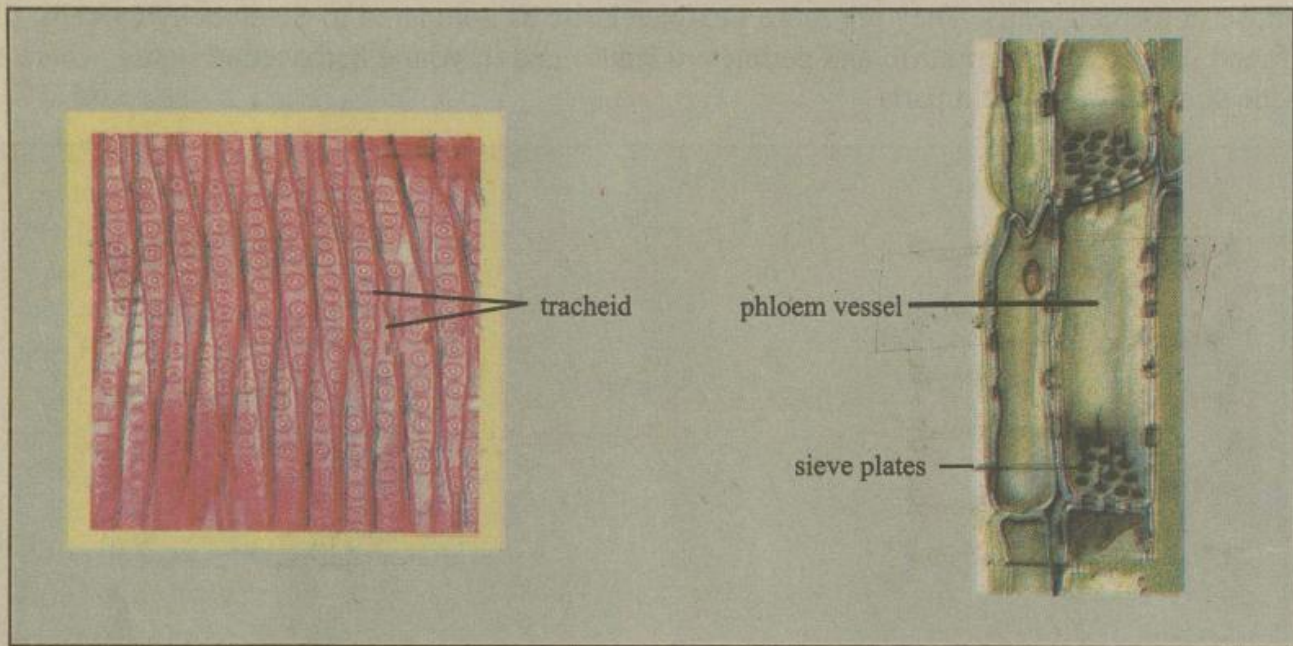


Fig. 2.19 (a) Xylem tissue

(b) Phloem tissue

2.4.2 Animal Tissues

Animal tissues are divided into four major types.

- | | |
|------------------------|-------------------------|
| (i) Epithelial tissues | (ii) Connective tissues |
| (iii) Muscle tissue | (iv) Nerve tissue |

These four types are further divided into sub-types according to their functions or location. A few of them are explained briefly.

(i) Epithelial Tissue

They are found as outer most layer of an organ, or as lining of body invaginations and tubular parts. Structurally, these cells are flattened and elongated. They may form one or more layers of epithelial tissues of skin called squamous epithellium, providing protection. Some cells are cubicle in shape They are called cuboidal epithelial cells. They line the glandular ducts and help in the production of cell secretions. Some cells are small and elongated and are found at various places in the cavities of the organs, these are called columnar epithelial cells. e.g. cells of gastric glands in stomach which secrete the gastric

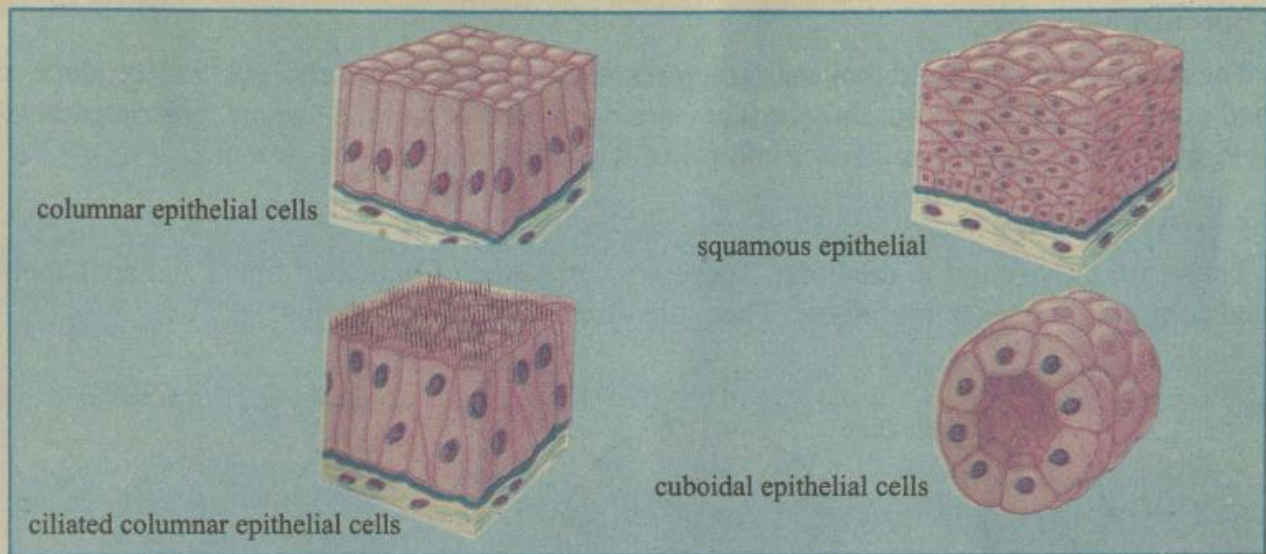


Fig. 2.20 Types of epithelial tissues

juice. Some columnar cells have cilia at their free surface. These are called ciliated epithelial cells. e.g. Cells present in trachea. Due to the movement of these cilia, mucus and other materials are expelled.

(ii) **Connective Tissues**

This is composed of semi fluid matrix containing a variety of cells and fibers. It is the major supporting tissue of the body and some of its other functions are packing and binding of structures. They provide protection against microbial invasion and also help in the production of blood cells. There are two types of connective tissues. Fatty tissue and tendons are the examples of soft connective tissue. Cartilage and bone are examples of hard connective tissue. Blood is also a special connective tissue with cells suspended in a fluid medium. It transports materials in the body.

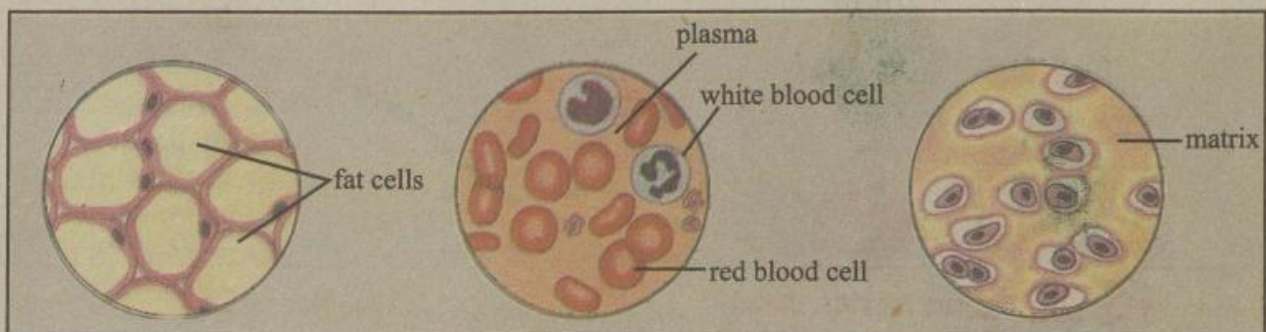


Fig. 2.21 (a) Adipose tissue (b) Plasma, a special connective tissue (c) Hard connective tissue

(iii) **Muscular Tissue**

This tissue is composed of contractile cells or fibers. Each muscle fiber is an elongated cell, which has the ability to contract and relax. This tissue causes movement of the body and body parts. Three types of these tissues are found in our body.

(a) **Skeletal Muscles**

These are attached to the cartilage and bones. Under a microscope these appear as striped fibers, and are called striped or striated muscles .i.e these are voluntary muscles, which produce powerful, rapid contractions and help our arms and legs to move.

(b) Smooth Muscles

These are found around hollow structures such as blood vessels, gut and produce slow, sustained contractions but do not fatigue. They are composed of spindle-shaped, unstriated muscles. These are involuntary and are under the control of the autonomic nervous system.

(c) Cardiac Tissues

These are only found in the heart. These are composed of branched fibers and are capable of sustained contraction but do not fatigue. These are also involuntary in action.

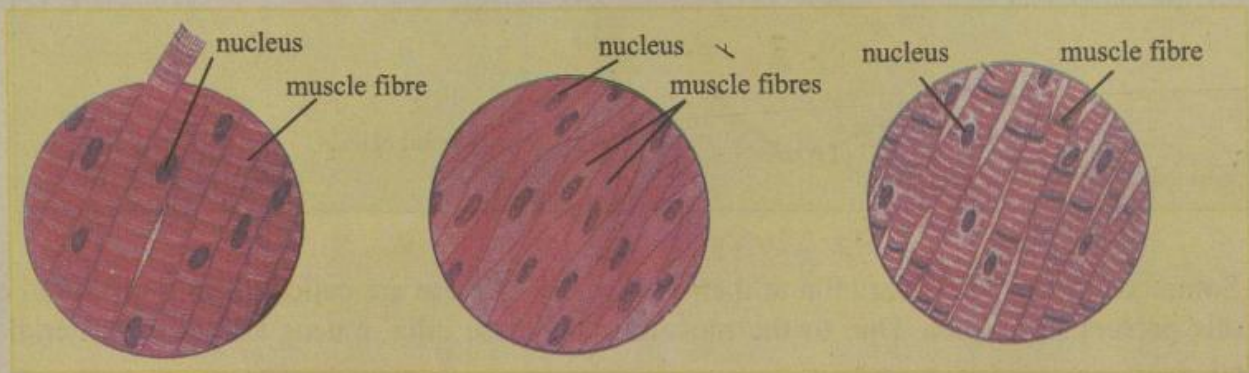


Fig.2.22 (a) Skeletal muscles (b) Smooth muscles (c) Cardiac muscles

Nervous Tissue

It is composed of nerve cells, which are called neurons. Each neuron consists of cell body with dendrites and axons. These produce nerve impulse to conduct messages and are also connected to various parts of the body. These are found in nerves and in the central nervous system e.g brain and spinal cord.



Fig. 2.23 (a) Nerve tissue

(b) Nerve Cell

2.6 Unicellular Organism *Amoeba*

If you take a drop of water from ponds or stagnant pools and observe it under microscope, you will see small organisms. One of them (does not possess a permanent shape) is *Amoeba*. In ponds it is found moving about around the weeds and stones. Some species are found in the damp soil. *Amoeba* is a protist, so it is microscopic in size, measuring 0.25 millimeter. Its structure is very simple. It consists of a nucleus and cytoplasm that is surrounded by cell membrane which protects it. Cytoplasm is differentiated into two parts, outer clear and transparent part is called ectoplasm while the inner, viscous translucent and granular part is called endoplasm. Food vacuoles of different sizes, a contractile vacuole, different organelles i.e mitochondria, Golgi bodies, ribosomes and nucleus are found in the cytoplasm. The food consisting of microbes found in water, is digested inside the food vacuoles. The concentration of water in the body is maintained by the

contractile vacuole, which removes the excess amount of water. Exchange of gases (respiration) and removal of waste materials is by simple diffusion through general body surface.

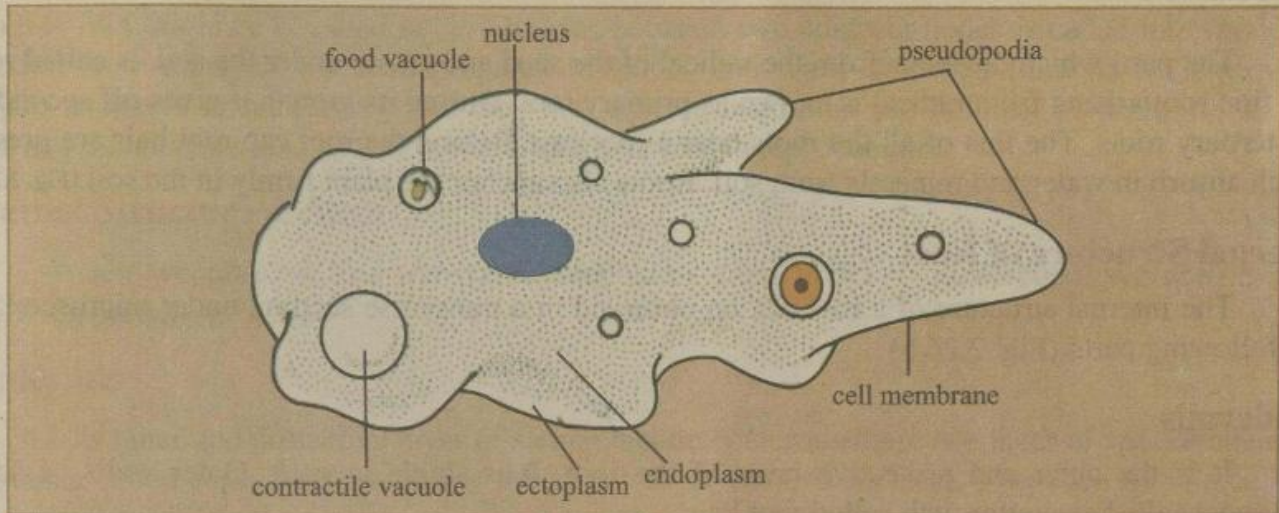


Fig.2.24 Amoeba

Nucleus changes its place with the movement of the organism. It keeps on changing its shape due to thin and flexible cell membrane. The movement of amoeba is called amoeboid movement. In favorable conditions an *Amoeba* divides into two by binary fission.

2.7 Multicellular Organisms

Brassica campestris/ Mustard Plant

This plant is sown in winter and at the end of the season it produces seeds and dies. It is used as vegetable, and its oil (mustard oil) is used for different purposes.

Structure of Mustard Plant

It consists of root, stem, branches, leaves and flowers. On functional bases these organs are divided into two categories. Vegetative parts, which do not directly take parts in sexual reproduction e.g root, stem, branches and leaves. Reproductive parts, which directly participate in sexual reproduction e.g flower, fruit and seeds.

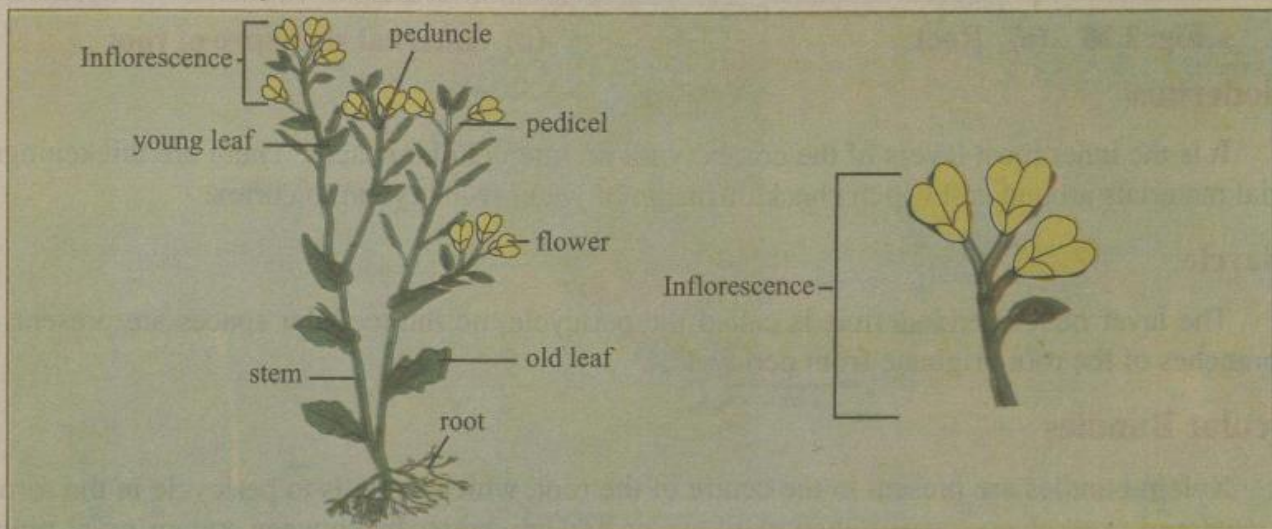


Fig. 2.25 Brassica Campestris (Mustard Plant)

2.7.1 Vegetative Parts

Root

The part, which develops from the radical of the seed and grows under the soil, is called root. The first root arising from radical is known as primary root. During its growth it gives off secondary and tertiary roots. The tips of all the roots bear a root cap. Behind the root cap root hair are present which absorb in water and minerals from soil. Roots also anchor the plant firmly in the soil. (Fig. 2.26 a)

Internal Structure of Root

The internal structure of a root can be observed in a transverse section, under microscope. It has following parts. (Fig. 2.26 b)

Epidermis

It is the outer and protective layer of the root. It is single layered. Outer walls of some epidermal cells have outgrowth called root hair.

Cortex

Lying inside epidermis is the cortex. It is composed of many layers of thin walled living cells (parenchyma cells) with intercellular spaces. Food is stored in the cortex.

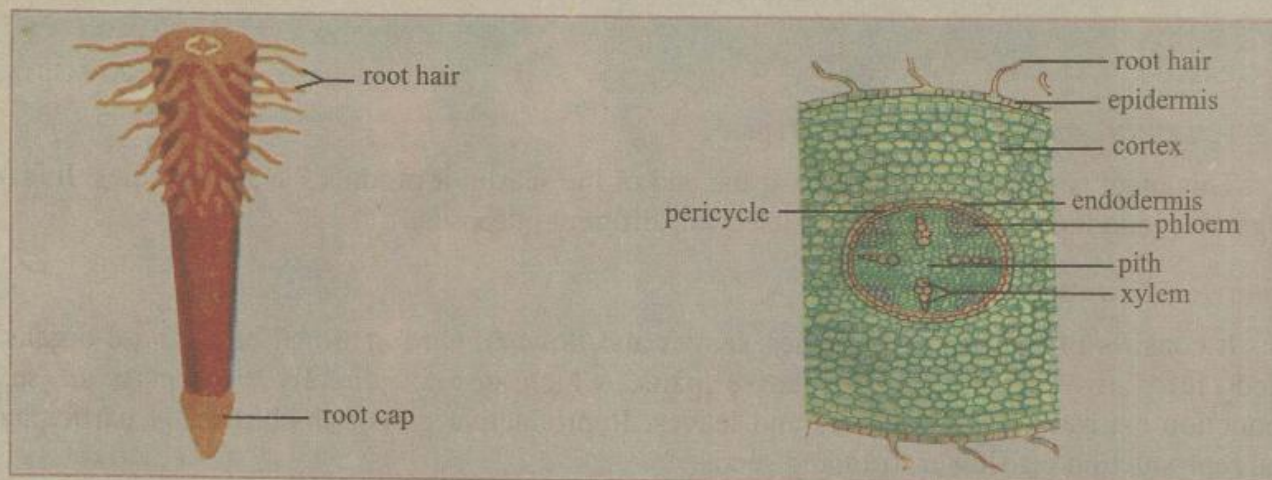


Fig. 2.26 (a) Root

(b) Internal structure of root

Endodermis

It is the inner most layers of the cortex, with no intercellular spaces. There are thickenings of special materials around cell which check diffusion of water from xylem to cortex.

Pericycle

The layer next to endodermis is called the pericycle, no intercellular spaces are present. All the branches of the root originate from pericycle.

Vascular Bundles

Xylem bundles are present in the centre of the root, which extends to pericycle in the form of four rays and control one way transport of water and minerals. In between xylem rays, phloem bundles are present, which transport food in both ways. (Fig. 2.26.b).

Stem

The part, which develops from the plumule of the seed and grows away from soil, is called stem. It is herbaceous and branched. It bears leaves and flowers. The part of stem or branch from which leaves originate is called node. The part between two adjacent nodes is called inter-node. Its function is to transport the food prepared in leaves and water absorbed from roots. It provides support to leaves in such a way that they may receive maximum sun light for preparing food. The stem and its branches also bear flowers, which take part in reproduction.

Internal Structure of Stem

When we observe, the transverse section of stem under a microscope, we can see the following parts.(Fig. 2.27)

Epidermis

It is outer and protective layer of stem. Outside epidermis there is a layer of special chemical substance called cutin, which controls the excretion of water from stem. There are no intercellular spaces in the epidermal cells.

Cortex

It is next to epidermis and is made up of parenchyma and collenchyma tissues. Their function is to store food and water.

Endodermis

Innermost layer of cortex is called the endodermis. It is not prominent in stem. This layer controls the transport of water from xylem to cortex.

Pericycle

Pericycle is found in the form of bundles in between the endodermis and vascular bundles. It is composed of sclerenchyma cells and forms bundle cap. All the branches of the root originate from it.

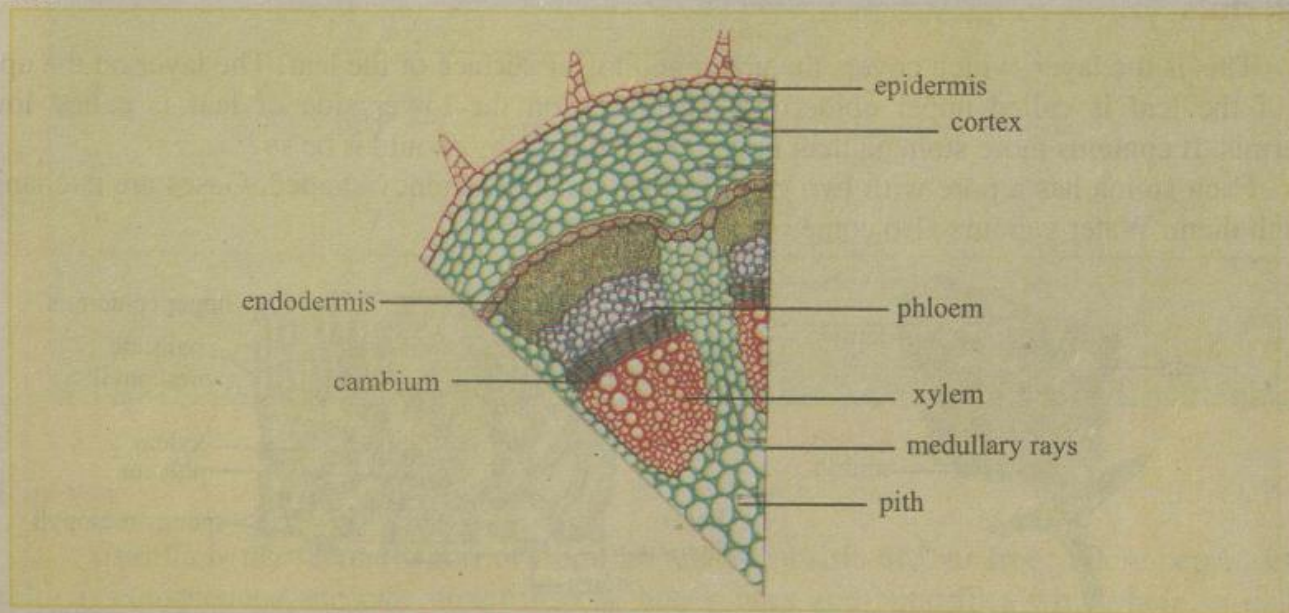


Fig. 2.27 Internal structure of stem

Vascular Bundles

In the stem rings of vascular bundles are present. Each vascular bundle consists of phloem (outside) and xylem (inside). In between xylem and phloem, a few layers of cells are present which are called cambium, which increases the thickness of the plant with the age.

Medullary Rays

In between two bundles, few layers of living thin walled cells, are present and are called medullary rays. They connect the cortex with pith for the transport of food.

Pith

The central part of stem is called pith. It is made up of living, rounded and thin walled parenchyma cells. It stores food.

Leaf

Leaves grow from nodes on stem and branches. Each leaf consists of two parts. Lower stalk like part is the petiole and the upper green expanded portion is called lamina. Young leaves are without petiole and their margins are entire or smooth. The leaves in lower part of stem are mature these are also without petiole but their margins are wavy. There is a thick (swollen) vein in the middle of leaf called midrib. The veins of different thickenings originate from midrib and spread in the leaf forming a network. This type of arrangement of veins is called reticulate venation. These veins consist of xylem and phloem tissues. The angle formed within the stem and leaf is called leaf axil. In the leaf axil buds are present which grow and become branches. The function of leaf is to prepare food for the plant. Upper and lower surface of leaf are different from each other such leaves are called bifacial leaves. (Fig. 2.28.a).

Internal Structure of Leaf

Like root and stem we shall study the following parts in the transverse section of the leaf as seen under a microscope. (Fig. 2.28.b).

Epidermis

This is the layer, which covers the upper and lower surface of the leaf. The layer on the upper side of the leaf is called upper epidermis. The layer on the lower side of leaf is called lower epidermis. It contains more stomata than upper epidermis. Why should it be so?

Each stoma has a pore with two guard cells, which are kidney shaped. Gases are exchanged through them. Water vapours also come out from these pores.

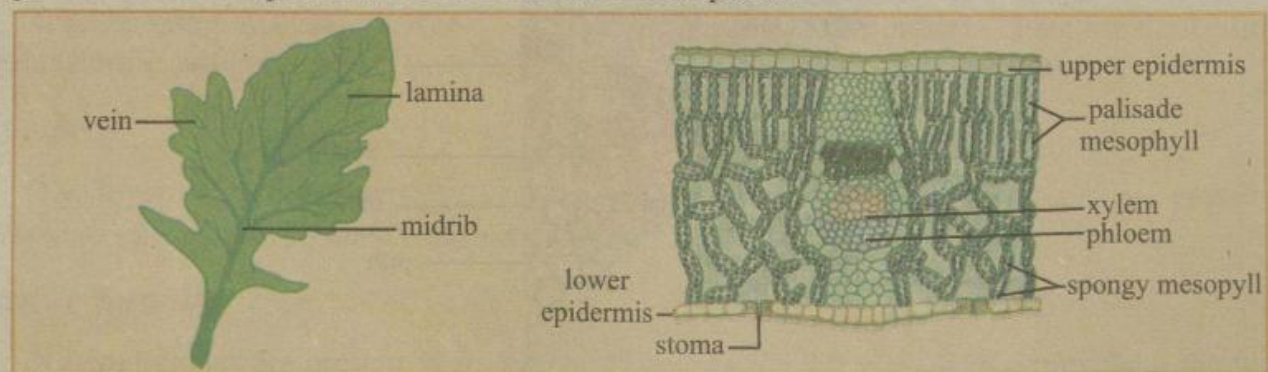


Fig. 2.28 (a) External structure of leaf

(b) Internal structure of leaf

Mesophyll

In between two epidermal layers, mesophyll is present. The part under upper epidermis has longer than broad cells, which are lying vertical. These are double layered closely packed cells, called palisade mesophyll. The lower part has more intercellular spaces and is sponge like. It is called spongy mesophyll. Both types of cells have chloroplasts containing chlorophyll. So photosynthesis takes place here. The function of mesophyll is to prepare food.

Vascular Tissue

Midrib and other veins form the vascular tissue. The upper part of the bundle of midrib is called xylem and lower part is called phloem. Pericycle and endodermis surround this bundle. Besides this lamina has other bundles which are called veins.

2.7.2 Reproductive Parts

Flower

Flower is a reproductive parts of the plant. With the maturation of age, the plant bears yellowish flowers. Flowers grow on young branches in a special way. This branch is called peduncle and the arrangement is called inflorescence.

Parts of Flowers

Flower consists of stalk and floral leaves. Stalk is called pedicel. The upper part of pedicle is comparatively swollen and is called thalamus. On thalamus floral leaves are arranged in four whorls.

Calyx

This is the outer most whorl of four sepals. On maturation, the light greenish color of sepals becomes yellowish. In young flowers sepals cover the inner parts of the flower. The basic function of calyx is to protect the inner parts of flower.

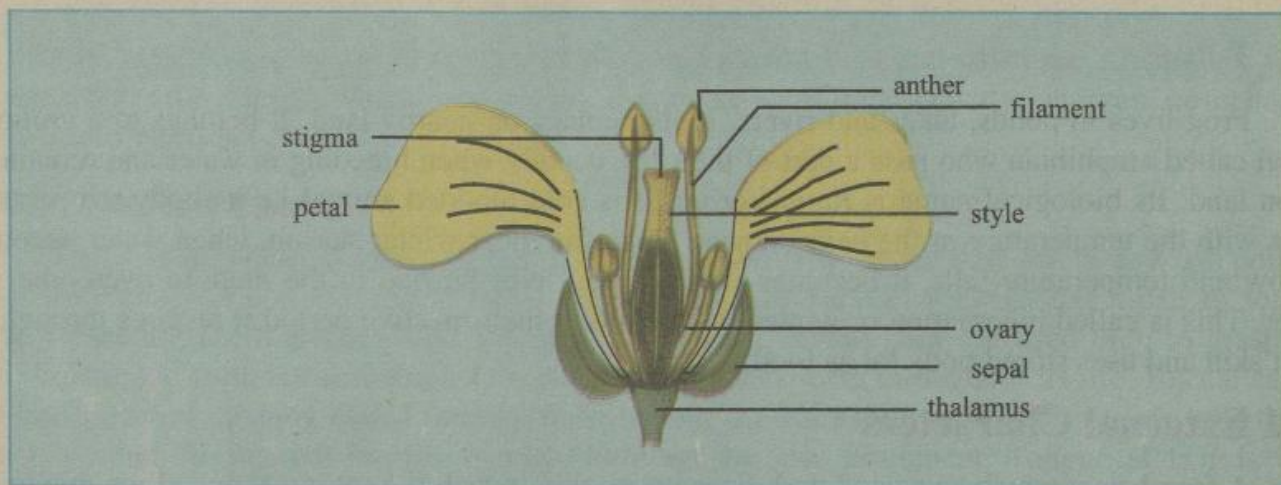


Fig. 2.29 Flower of Brassica

Corolla

Corolla is the second whorl of floral leaves. It consists of four free yellow petals. Its yellow color is conspicuous and can attract insects, honey bees and butterflies which help in pollination, (transfer of pollen grains from anther to stigma).

Androecium

Inside the petals is the third whorl, which is the male reproductive part. It consists of six free stamens. These are arranged in two circles: the outer circle has two small stamens, and the inner circle has four long stamens. Each has two parts. Lower stalk like part is called filament and upper swollen tip is called anther, which is full of pollen grains. When anther matures a longitudinal slit appears in its walls from which pollen grains escape. At the base of the filament four nectaries are present. When insects are attracted towards the flowers to collect this nectar, pollen grains get attached to their bodies and are transferred from one flower to another. This results in the pollination of flowers. (Fig. 2.30 a)

Gynoecium

This is the inner most part of the flower which is the female reproductive organ. It consists of two carpels, which are joined together. Each carpel has three parts. The lower most swollen part is called ovary. The ovary extends in to stalk like part called style. The tip of style is slightly swollen. It is called stigma. Ovary has many ovules. Ovules ripen into seeds. The ovary converts into fruit. The fruit of *Brassica* is called silique. It is a capsule like fruit having many seeds, which on becoming dry burst from below to upwards through valves. Seeds fall out and being small and light they are dispersed by air. (Fig. 2.30 b)

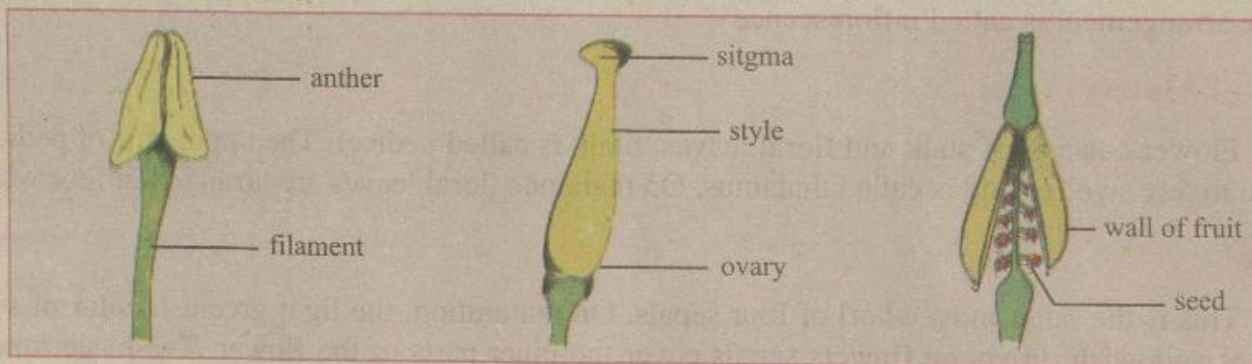


Fig. 2.30 (a) Androecium

(b) Gynoecium

(c) Fruit of *Brassica*

2.8 Frog

Frog lives in ponds, lakes and rivers. It also comes on nearby land. It belongs to a group of animal called amphibian who pass a part of their life usually when breeding in water and remaining life on land. Its biological name is *Rana tigrina*. It is cold blooded animal i.e its body temperature varies with the temperature of the environment. Therefore near winter season, when water becomes shallow and temperature falls, it becomes sluggish and lives buried in the mud to overcome the winter. This is called hibernation or winter sleep. During their inactive period it respire through its moist skin and uses stored body fat as food.

2.8.1 External Characters

A frog has greenish spots and dark lines on its skin, which is kept moist and slimy due to the secretion of glands. Its ventral side is yellowish white in colour. (Fig. 2.31a). Body of the frog consists of head, trunk and limbs, Neck and tail is absent, head directly joins with trunk, and therefore it cannot move his head. Head is triangular and flattened with a wide mouth on the anterior side. On the dorsal side and anterior side of the head, a pair of external nostrils are present. Two bulging eyes are present, which are covered with immovable eyelids along with a transparent nictitating membrane which can spread over the eye for its protection.

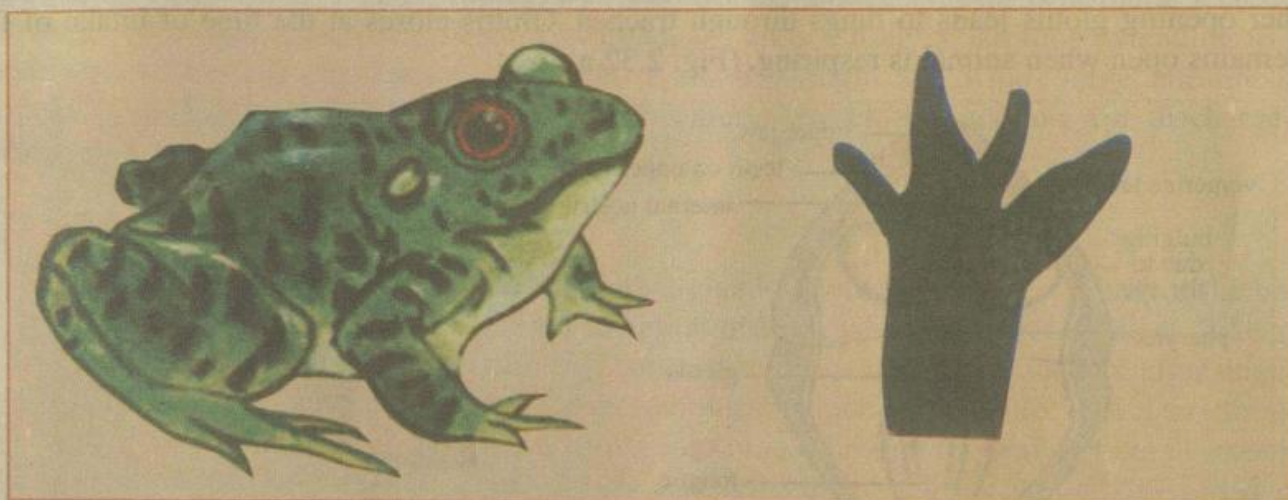


Fig. 2.31 (a) Frog

(b) First finger of frog in breeding season

Behind each eye on ventrolateral side of the head, a circular pit covered by tympanic membrane exists. This is the ear. Between the two hind legs, at the posterior end of the body an opening called cloaca is present which is concerned with discharge of undigested food, urine and reproductive fluid. It has small forelimbs and strong, long hind limbs with the help of which it can take long leaps. Hind legs have webbed fingers which help in swimming. In the forelimb four fingers are present in each hand, whereas hind limbs have five fingers each. In the male frog a finger of hand is padded which becomes more rough and swollen during breeding season. A pair of vocal sacs is present in the male, which appears like balloons during croaking.

2.8.2 Internal Organs

Body cavity of the frog is called coelom, which contains many internal organs forming different systems, the details of which are given below.

Digestive System

This system consists of alimentary canal, some glands, liver and pancreas. Alimentary canal is long coiled tube through which food passes. It is made up of buccal cavity, pharynx, oesophagus, stomach and intestines.

Buccal Cavity and Pharynx

There is a mouth between upper and lower jaw. The upper jaw has a row of pointed maxillary teeth, which are absent in the lower jaw. Roof of the buccal cavity has a pair of sets of vomerine teeth. Teeth are not used for chewing of food, instead they are used only to grasp the food. In frog old teeth are continuously replaced by the new teeth throughout its life. Buccal cavity also has a pair of opening called internal nostrils near the vomerine teeth. These leads to external nostrils. Behind the internal nostrils two eye bulgings are also prominent. Tongue of frog is very sticky and is attached at the anterior end of the buccal cavity whereas it is free and bifid from behind. Frog is an insectivorous animal. To capture its prey it suddenly throws its tongue on to the prey, which sticks to tongue and is brought to the buccal cavity when the tongue is drawn back.

Near the maxillary joints a pair of opening of eustachian tubes are present. Male frog also has an additional pair of opening of vocal sacs on the lateral side of floor of the buccal cavity, which help the croaking. Buccal cavity narrows posteriorly to form the pharynx. Digestive system, respiratory system and ears separately open into the pharynx. In posterior part of the pharynx,

another opening glottis leads to lungs through trachea. Glottis closes at the time of intake of food but remains open when animal is respiring. (Fig. 2.32.a).

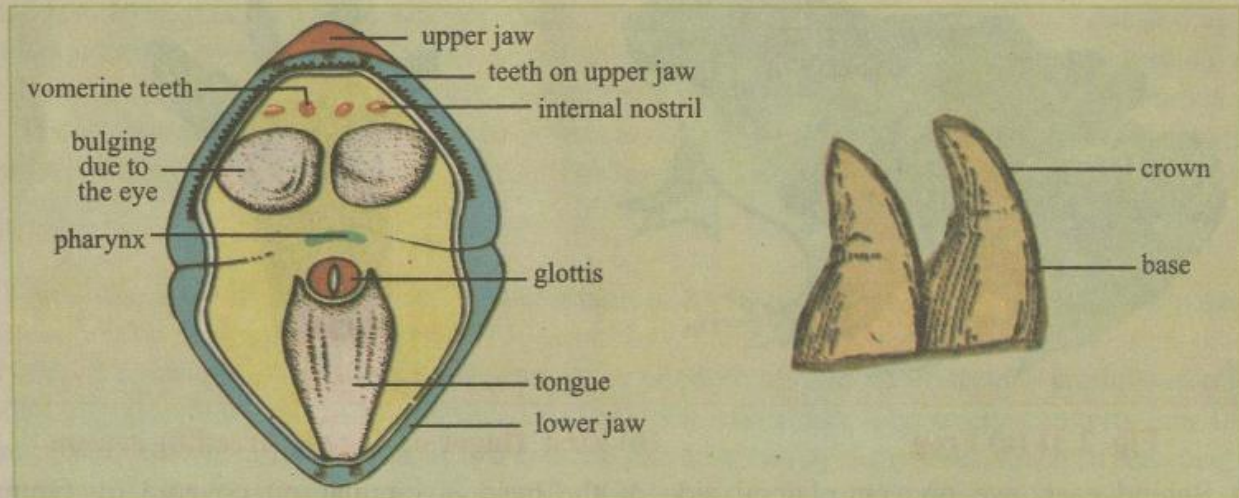


Fig. 2.32 (a) Buccal Cavity

(b) Two teeth of Frog



Fig. 2.33 The way to capture prey by tongue

Oesophagus, Stomach and Intestine

Pharynx leads to a small wider tube called oesophagus or gullet, which opens into the stomach. Anterior end of stomach is called cardiac end and posterior end is called pyloric end. Walls of the stomach are muscular and glandular. (Fig. 2.34).

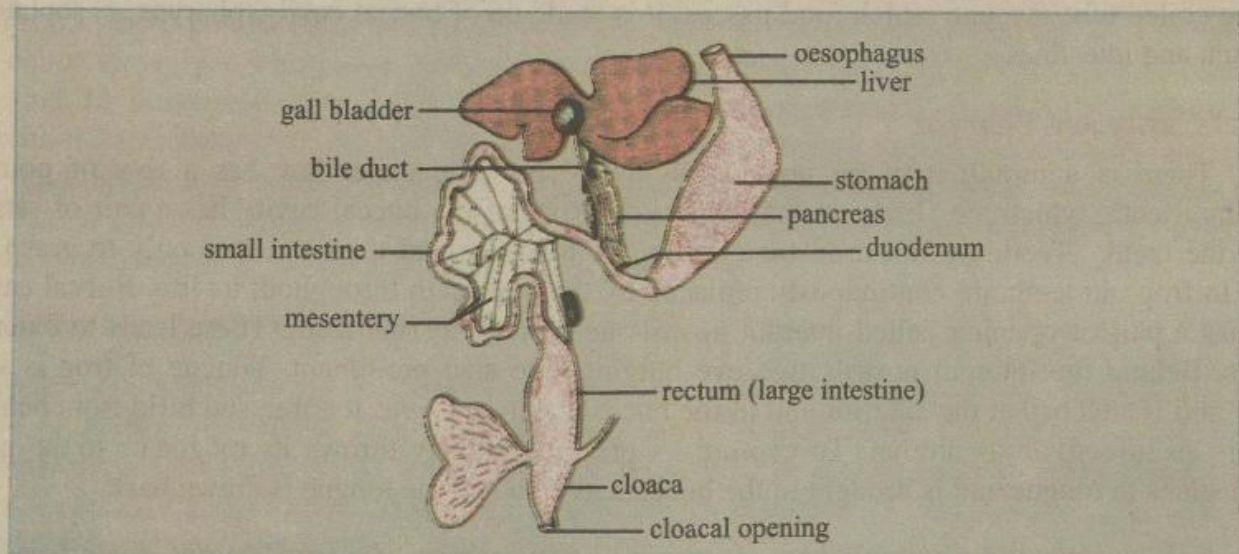


Fig. 2.34 Digestive System

Contraction and relaxation of muscular walls of stomach help to break the food into small pieces. Gastric secretions have enzymes which start digesting the proteins in food. After stomach,

the first part of small intestine called duodenum starts. Duodenum receives ducts bringing secretions from liver and pancreas. Duodenum leads into Ileum which is a long coiled tube extending to the posterior end of the abdomen. Ileum opens into a small, straight and wide "large intestine" or rectum. Rectum opens into cloaca which opens to exterior by cloacal aperture for discharge of undigested food and waste products.

Accessory Digestive Glands

Liver and pancreas are the accessory digestive glands. Liver is the largest gland of the body cavity located in its anterior region. Bile is the secretion of liver, which is stored in the sac like gall bladder. From gall bladder a thin bile duct originates which opens into the duodenum after running through the pancreas. Pancreas produces pancreatic juice, which enters into bile duct through smaller ducts. It helps to digest food for absorption into blood through the walls of small intestine (Ileum). Surplus water is absorbed in the rectum and remaining undigested food is voided out through cloaca. Mesentery is a membrane, which keeps the intestine intact at a place and prevent strangulation of small intestine.

Respiratory System

Frog has three methods of respiration.

1. Pulmonary Respiration
2. Cutaneous Respiration
3. Buccal Respiration

1. Pulmonary Respiration

Gaseous exchange through lungs is called pulmonary respiration. During this process frog keeps its mouth closed. Air enters into the buccal cavity through nostrils. Nostrils are closed, floor of the buccal cavity is raised, glottis opens and air is pushed into the lungs. Intake of air is called inspiration. Pair of balloon shaped lungs is present in a frog. Each lung consists of small thin walled chambers called alveoli, which greatly increases the surface area of the lungs. Each alveolus is richly supplied with capillaries and exchange of gases takes place between the blood in these capillaries and air filled then air moves out of lungs back through nostrils. Frog uses its nostrils and floor of buccal cavity for inspiration and expiration of air. (Fig. 2.35).

Gaseous exchange also occurs between the blood in the capillaries of buccal cavity and air. When air is present in the buccal cavity.

In frog, air is pushed into the lungs through pumping pressure of buccal cavity while in man air is sucked into lungs due to the decrease in pressure in the thoracic chamber.

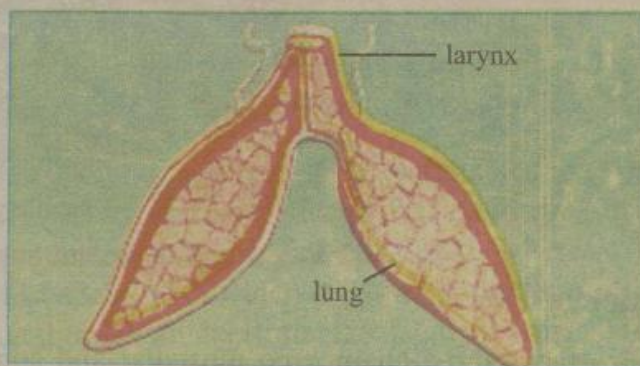


Fig. 2.35 Respiratory System of Frog

Oxygen present in the air dissolves in the moisture present on the inner lining of the lungs and diffuses into blood where it combines with haemoglobin to form oxyhaemoglobin compound. This oxygenated blood circulates through capillaries to all parts of the body. Where oxygen separates from oxyhaemoglobin molecules and is absorbed by the cells. Carbon dioxide from cells comes out into blood which carries it to the lungs and from here carbon dioxide is discharged out.

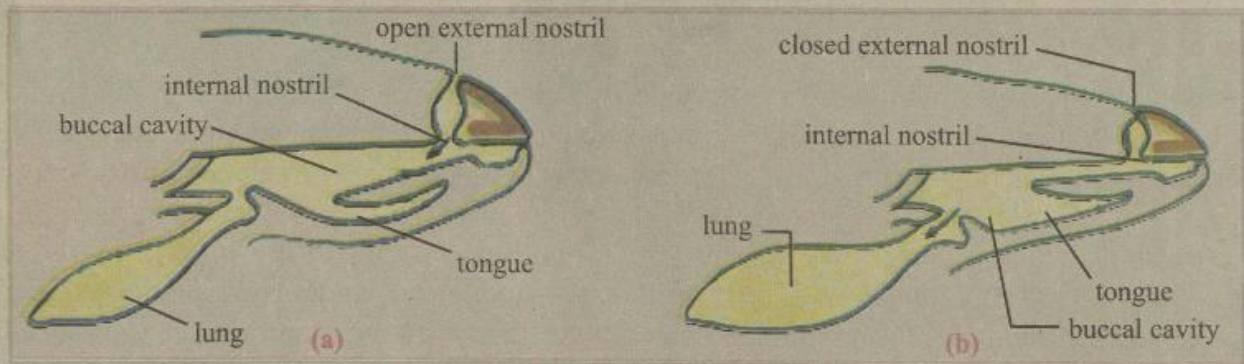


Fig. 2.36 Two stages in respiration

2. Cutaneous Respiration

During hibernation and swimming gaseous exchange is carried out by skin. Skin is moist and richly supplied with capillaries. Oxygen diffuses through skin to capillaries and is carried by blood and carbon dioxide diffuses back to blood from cells and is discharged out.

3. Buccal Respiration

Buccal cavity has moist surface, richly supplied with capillaries so exchange of gases occurs in the buccal cavity.

Circulatory System

Circulatory system of frog consists of blood vascular and lymphatic systems.

Blood Vascular System

Blood vascular system of frog consists of a strong pumping organ the heart, arteries, veins and capillaries.

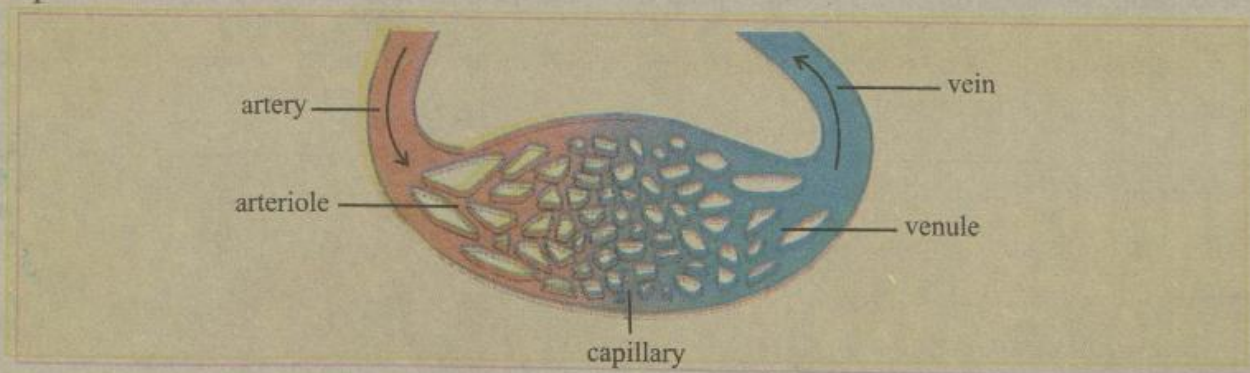


Fig. 2.37 Veins, arteries and capillaries in the web of frog

Structure of Heart

Heart is a three-chambered muscular and conical organ located in the body cavity between the oesophagus and sternum. It works like a pump, contracting and relaxing due to which blood

continuously circulates in the body. It is enclosed in a membranous pericardium. Three chambers of heart are:

1. Right Atrium
2. Left Atrium
3. Ventricle

The two thin walled atria forms the broader anterior part of the heart. Right atrium is of larger size than left atrium. Ventricle forms the conical thick, uneven walled, posterior part of the heart.

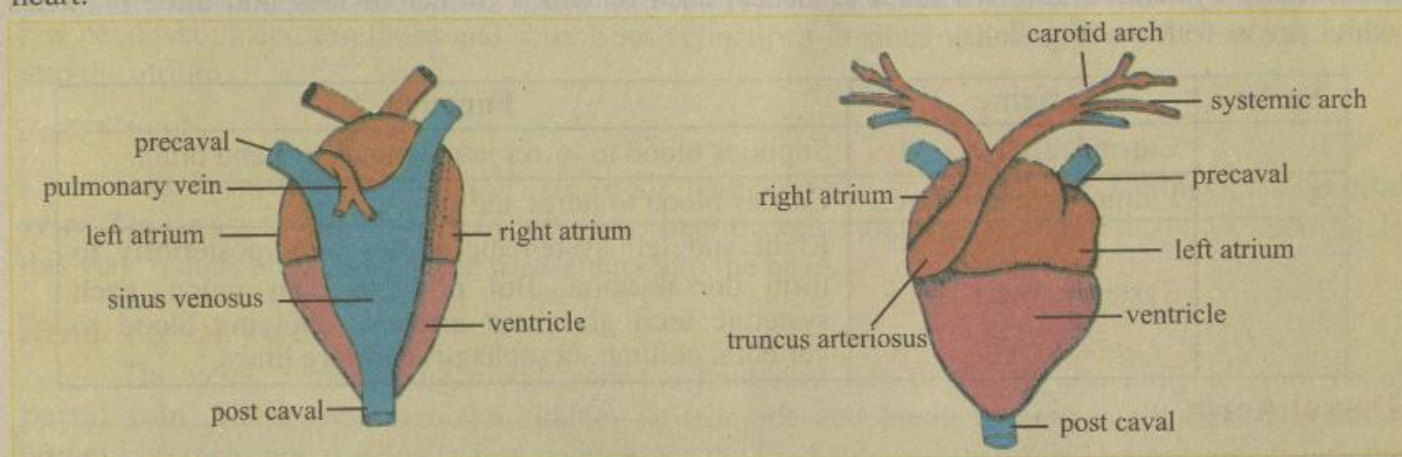


Fig. 2.38 Heart of frog (a) Dorsal side

(b) Ventral side

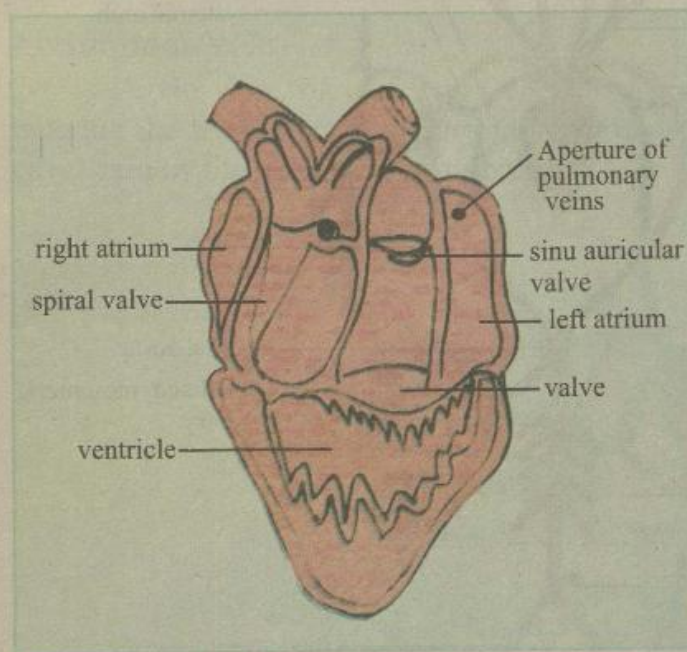


Fig. 2.39 Internal Structure of heart

A broad vessel, the truncus arteriosus originates from the dorsal side of the ventricle and divides into two branches near atria. A thin walled triangular sinus venosus opens into the right atrium. Some biologists consider truncus arteriosus and sinus venosus as chambers of heart.

Chambers of the heart, beat in a rhythmic manner. First of all sinus venosus contracts, then the two atria followed by the contraction of ventricle and lastly truncus arteriosus contracts. Deoxygenated blood from the whole body, except lungs is carried to the sinus venosus by two precavals and one postcaval. Sinus venosus opens through an aperture into the right atrium. Oxygenated blood from lungs is carried to left atrium by two pulmonary veins. (Fig. 2.39)

Both the atria opens jointly by an aperture, guarded by a valve, into the ventricle. The valve maintains the unidirectional flow of blood in heart and does not allow the blood to flow back.

The two atria, right with deoxygenated blood and left with oxygenated blood contracts simultaneously to push their blood collectively into the ventricle. In the middle of the ventricle chamber, there is some mixing of the deoxygenated with oxygenated blood, whereas on the two sides the blood remains unmixed due to the fast speed with which it passes from ventricle. Ventricle contracts to push blood into truncus arteriosus through an aperture guarded by a valve. This aperture regulate the speed and direction of blood by a spiral valve present at the start of truncus arteriosus, this regulate makes the maximum amount of the deoxygenated blood to go to lungs and skin for

oxygenation, whereas mixed and oxygenated blood goes towards all parts of the body except lungs and skin for supplying oxygen to tissues.

Arterial System

Vessels carrying blood away from heart are called arteries, forming an arterial system. It is a distributary system. It has two main branches, each of which further divides into three branches which are as follows (Fig. 2.40).

Sr. No.	Name	Function
1.	Carotid arch	Supplies blood to lower jaw, tongue, eye and brain.
2.	Pulmocutaneous arch	Carries blood to lungs and skin.
3.	Systemic arch	Right and left systematic arches joint posteriorly to form dorsal aorta. But prior to their union, each systemic arch gives out arteries supplying blood to vertebral column, oesophagus and fore limbs.

Dorsal Aorta

Dorsal aorta runs along the vertebral column towards the hind limbs.

Coeliacomesenteric artery originates from dorsal aorta and supplies blood to digestive system.

Renal arteries supply blood to kidneys and genital organs.

Posterior mesenteric artery carries blood to rectum and **iliac arteries** to hind limbs of their sides. All the arteries after reaching their regions of supply branch and re-branch into smaller

thin walled vessels, called capillaries. Through their thin walls exchange of materials between blood and tissue cells takes place. Capillaries join to form venules which forms veins and carry blood back to the heart.

Venous System

The vessels, which bring back the blood from different parts of the body to the heart, are called veins. The system consisting of veins is called venous system. In frog, this system consists of following veins. (Fig. 2.41).

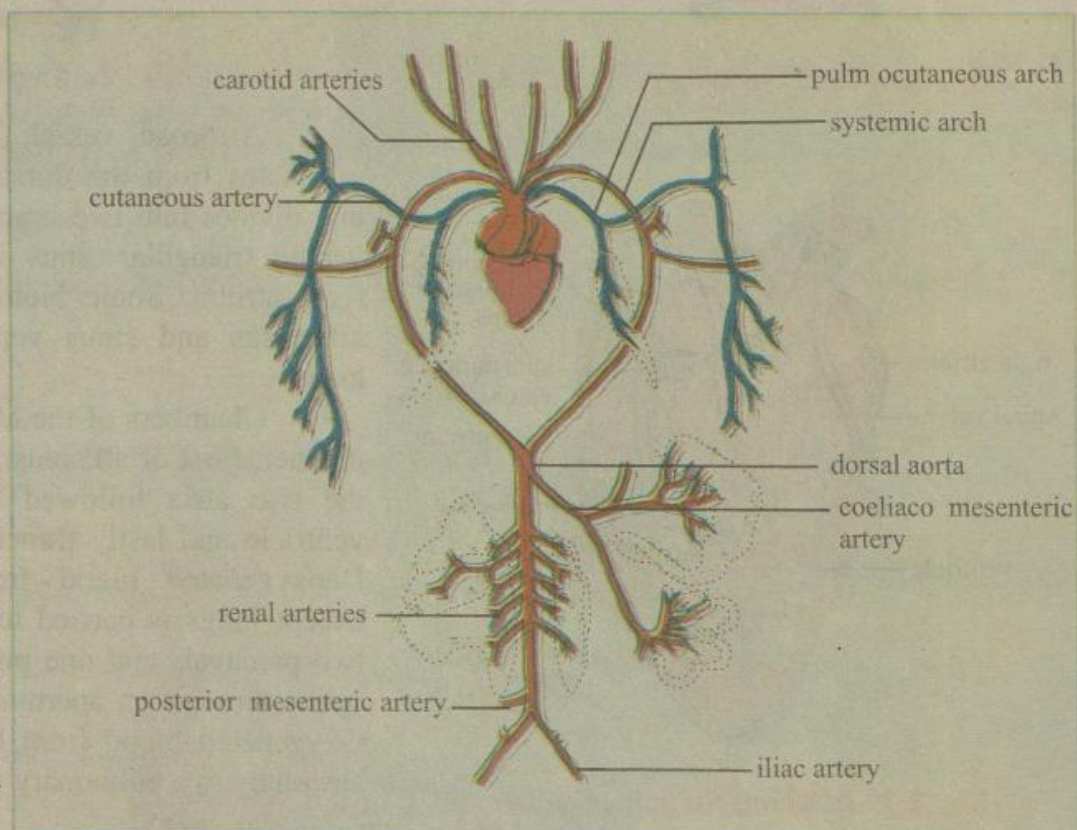


Fig 2.40 Arterial system

Pulmonary Veins

Blood from right and left lungs comes into the left atrium through a pair of pulmonary veins. Pulmonary veins have oxygenated blood.

Right and left Precavals

Each precaval is formed by the union of three veins which bring blood from tongue, lower jaw head, shoulders, forelimbs and skin. Both veins open in sinus venosus. From here blood comes into the atrium.

Post Caval

It is formed by the union of five or six pairs of renal veins from the kidneys and **genital veins**. On passes through liver it receives two **hepatic veins** and then enters in the sinus venosus. In this way venous blood from these parts enters into the heart.

Renal Portal Vein

The veins, which bring blood from the hind limbs and pelvic region, unite to form **renal portal vein**. These enter into the kidney of it's side and break up into capillaries. The blood brought by renal portal veins is first poured into the kidneys and then renal veins carry it into the post caval vein, which finally carries it to the heart.

Abdominal Vein

Pelvic veins of both sides unite to form **abdominal vein**, which divides into two before entering the liver. Here it divides into capillaries. The blood from the liver is drained into the post caval vein by the hepatic veins of both sides.

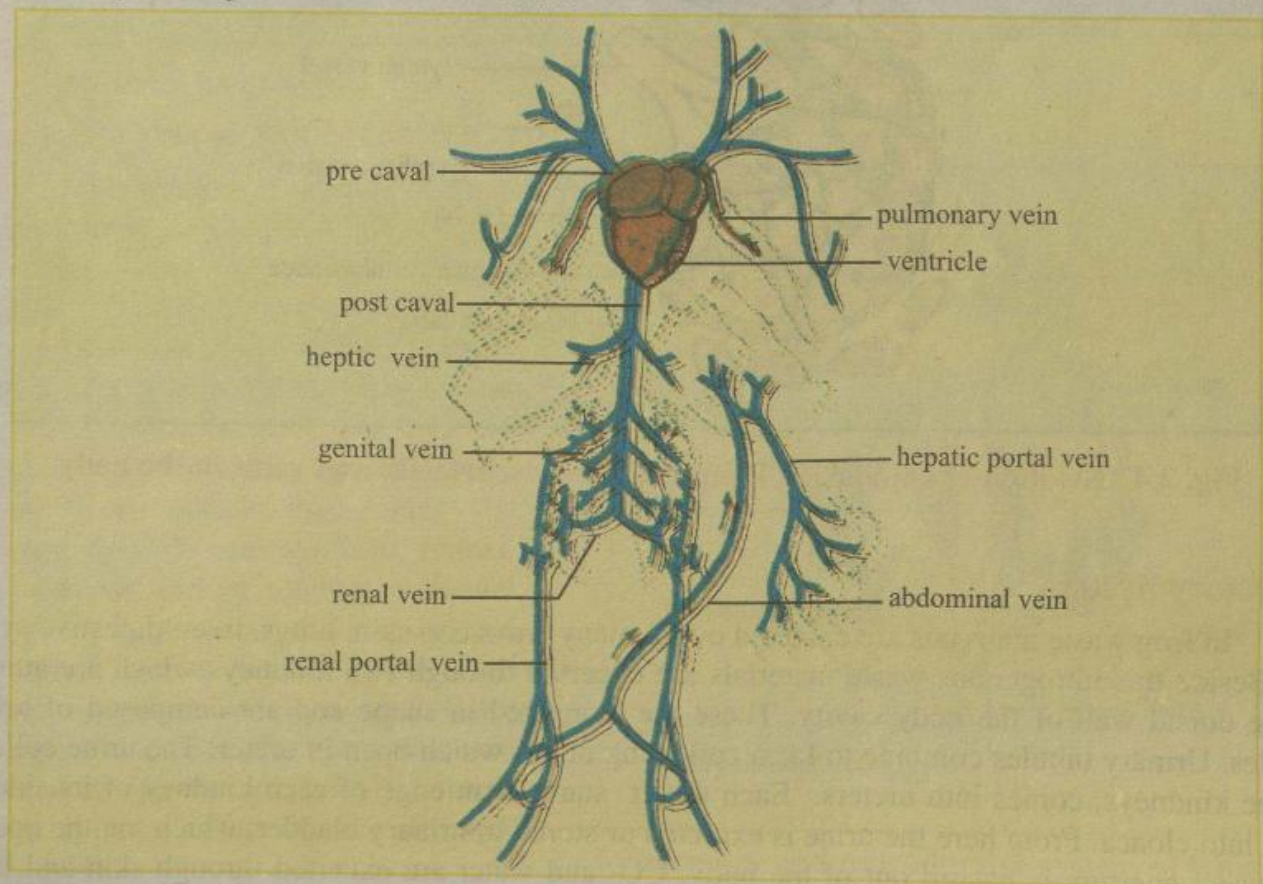


Fig. 2.41 Venous System

Hepatic Portal Vein

The blood vessels from various parts of digestive system e.g. stomach, duodenum, ileum, rectum, pancreas and spleen collectively fuse to form a large vein called hepatic portal vein. In liver it unites with abdominal vein and then divides and re-divides into capillaries. The blood on reaching the liver through hepatic portal veins enters the post caval by hepatic veins. The blood from post caval finally enters the heart through sinus venosus. In short the blood received by the heart during circulation is of two types.

1. **Oxygenated Blood:** Received from lungs through pulmonary veins, enters the left atrium.
2. **Deoxygenated Blood:** From all parts of the body through pre-caval and post-caval enters into sinus venosus and then into right atrium.

Lymphatic System

During the circulation of blood, due to the pressure of blood some of the blood plasma leaves the capillaries. It is in the form of a clear watery fluid, which fills the intercellular spaces. It is called interstitial fluid. Much of it re-enters the capillaries and some of it enters into the lymph vessels it is called lymph. The flow of lymph is one sided. Lymph through lymph vessels enters into big veins. So lymph again enters into blood. Lymph keeps tissues wet and helps in transport of different materials from blood to tissues and vice versa.

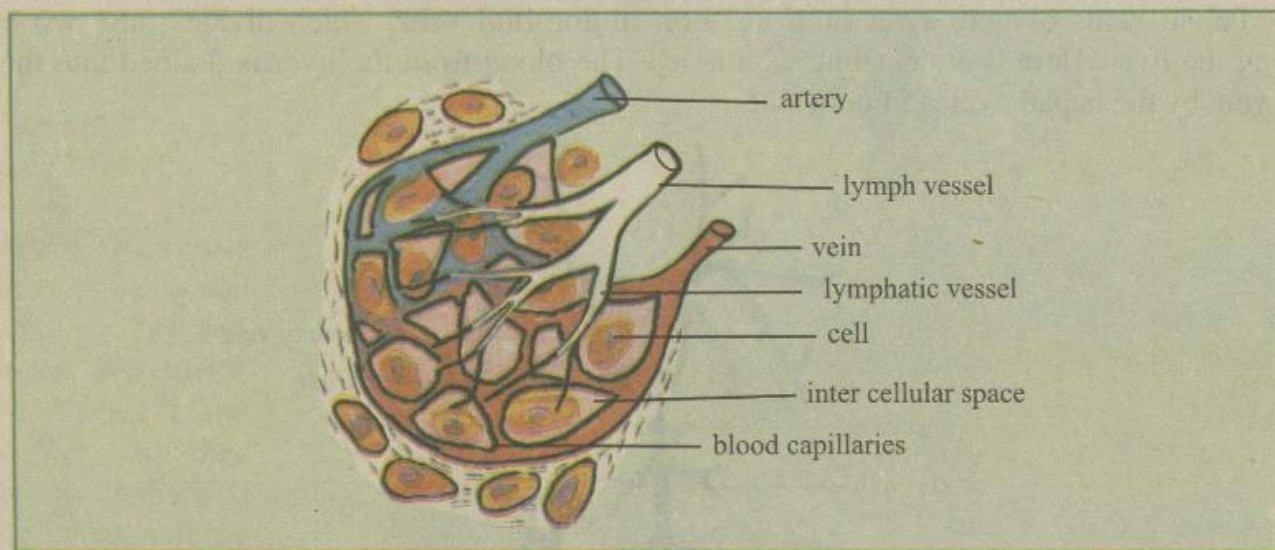


Fig. 2.42 Relation of capillaries, lymphatic vessels, arteries and veins in the body

Excretory System

In frog waste materials are excreted out in many ways.e.g. skin, lungs, liver, digestive system etc. Beside this nitrogenous waste materials are excreted through two kidneys which are attached to the dorsal wall of the body cavity. These are elongated in shape and are composed of urinary tubules. Urinary tubules combine to form collecting ducts, which open in ureter. The urine collected by the kidneys, comes into ureters. Each ureter starts from edge of each kidney of its side and open into cloaca. From here the urine is excreted or stored in urinary bladder, which on the opening of cloacal aperture is passed out of the body. CO_2 and water are excreted through skin and lungs, while through liver and digestive system undigested food and some waste materials are excreted.

Male Reproductive System

The reproductive system of male frog consists of a pair of testes and reproductive ducts. Testes lie on the ventral surface of the kidney of their side and are attached to them by a membrane. Fat bodies are present at their anterior ends. Each testis is composed of seminiferous tubules, in which sperms are formed. Sperms pass into kidney through fine tubes called vasa efferentia (single vas efference). From ureter sperms pass into cloaca and are discharged out into water. In male, ureter performs double function, the excretion of urine and sexual material, so it is called **urinogenital duct** and the urinary system and the genital system are associated into urinogenital system. (Fig. 2.43).

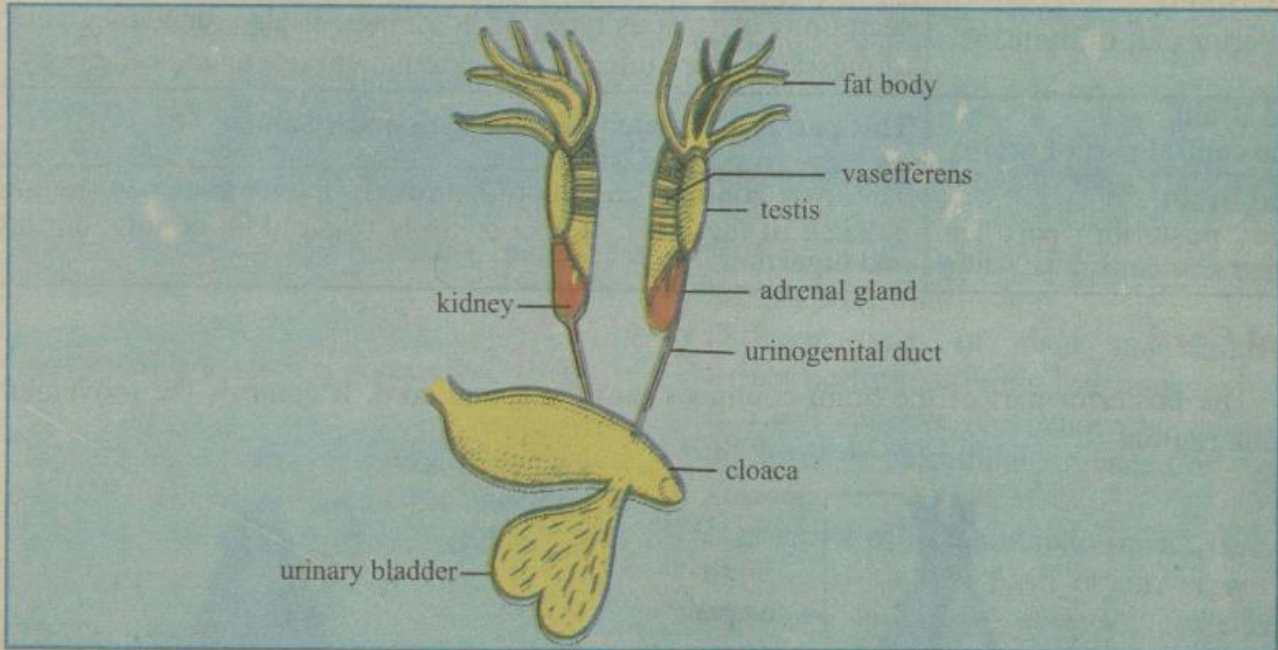


Fig. 2.43 Urinogenital system of frog

Female Reproductive System

This system consists of two ovaries and reproductive ducts. Ovaries are located near the kidneys. At their anterior end fat bodies are present. Each ovary has numerous follicles where eggs are formed. In the breeding season ovaries increase in size. The ova are released from the ovary into the body cavity from where they enter the oviduct through the oviducal funnel. The anterior end of oviduct is funnel like while the posterior end is broad and is called uterus which opens into cloaca. Eggs are released into water through the cloaca. In water a sperm fertilize an egg and a zygote is formed. From zygotes offspring are formed. (Fig. 2.44).

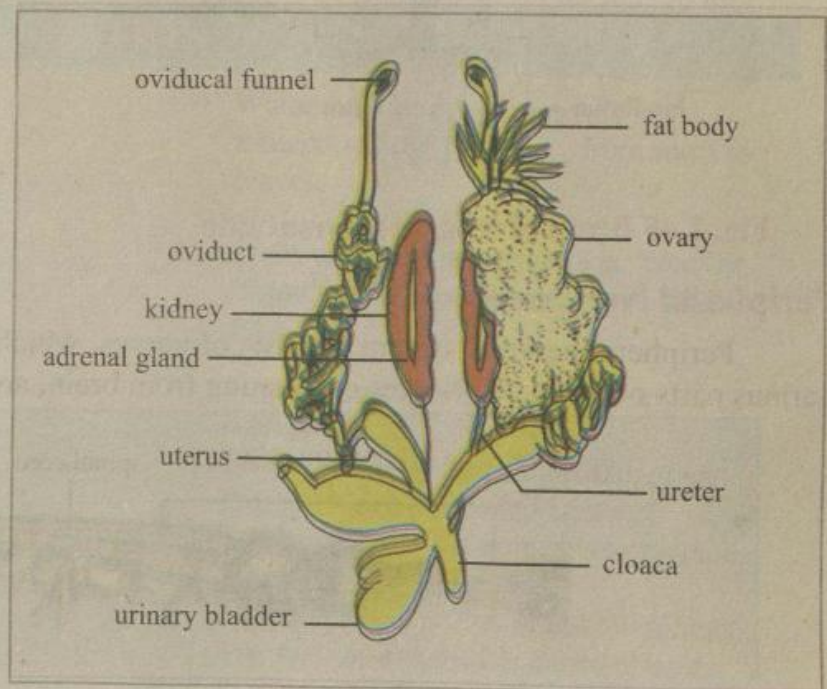


Fig. 2.44 Excretory and reproductive system of female frog

Nervous System of Frog

It consists of central nervous system and peripheral nervous system.

Central Nervous System

It includes the brain and spinal cord. Brain is enclosed in protective layers and is located in cranium or brain case, which is the major portion of skull. Brain has three parts, which are called, Fore brain, mid brain, hind brain.

Parts of Brain	Functions
Fore Brain. (Anterior part of brain)	This part is associated with sense of smell. It controls the secretions of various types of hormones. It also receives a variety of messages from internal and external environment of the body.
Mid Brain. (The central part of brain)	This part is associated with the eyes and vision.
Hind Brain. (The posterior part of brain)	This part controls and coordinate body movements and maintain balance of the body. It also controls respiration, circulation, taste and digestion.

Spinal Cord

The posterior part of the brain continues into the spinal cord. It controls the movements of the trunk region.

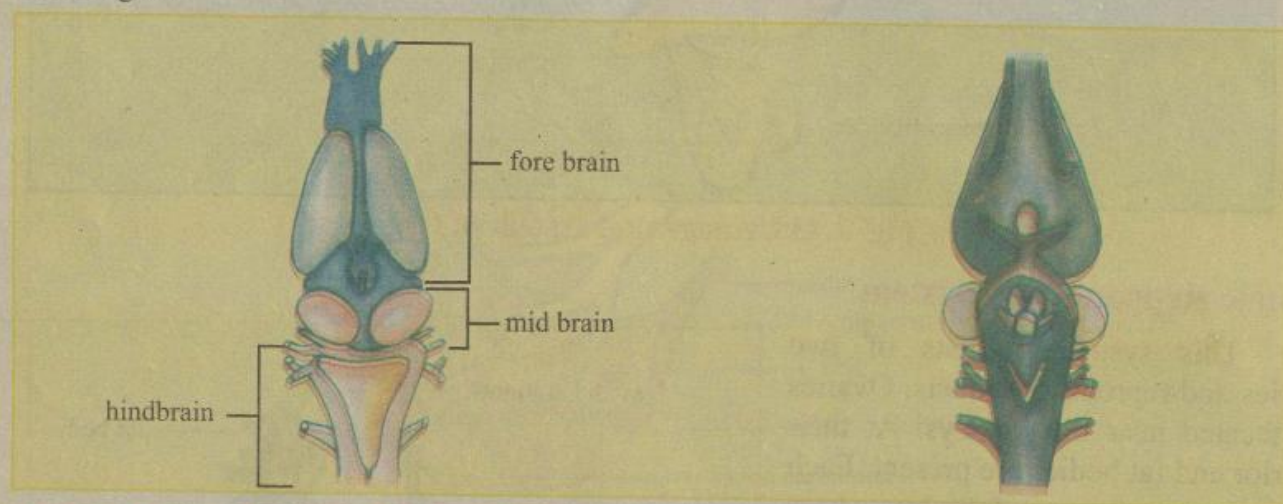


Fig. 2.45 Brain of frog (a) Dorsal side

(b) Ventral side

Peripheral Nervous System

Peripheral nervous system consists of nerves, which connect the central nervous system with various parts of the body. Nerves originating from brain, are called cranial nerves.

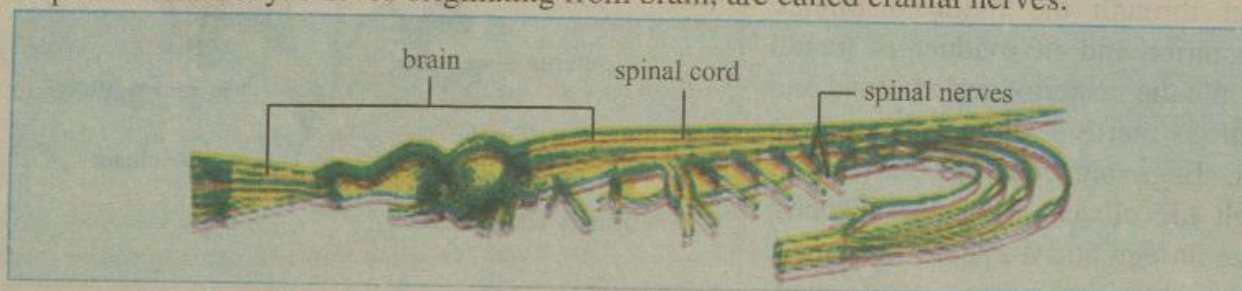


Fig. 2.46 Central and peripheral nervous system of frog

Nerves originating from spinal cord are called spinal nerves. In frog there are ten pairs of cranial nerves and nine or ten pairs of spinal nerves. Nerves are of following types.

1. **Sensory Nerves:-** These nerves take messages from sensory organs to central nervous system.
2. **Motor Nerves:-** These nerves take messages from central nervous system to glands and muscles.
3. **Mixed Nerves:-** These nerves do both the above mentioned functions.

In cranial nerves, first, second and eighth pairs are sensory nerves. Third, fourth and sixth pair are motor nerves which carry messages from brain to the eye. Ninth and tenth are mixed nerves, and are supplied to the jaw, face, tongue and heart. Spinal nerves are all mixed nerves and control functions of different organs. (Fig. 2.46).

KEY POINTS

- | | | | |
|---|--|---|---|
| 1 | Cell is a structural and functional unit of organisms. | 5 | A group of cells, which have same structure and functions, form tissues. |
| 2 | Cells divide to form new cells. | 6 | Different types of plant and animal tissues perform different functions. |
| 3 | Mitosis is a cells division in which number of chromosomes in daughter cells is similar to the number of chromosomes in parent cell. | 7 | If a cell can live independently, this is the level of unicellular organization e.g. <i>Ameoba</i> . |
| 4 | Meiosis is a cells division in which number of chromosomes in daughter cells reduces to half then the parent cell. | 8 | A group of cells combine to form tissue, tissues combine to form organ, organs combine to form system, systems combine to form an organism. This is called the organization of life, e.g. Mustard plant and frog. |

QUESTION

1. **Fill in the blanks.**
 - (i) In electron microscope _____ are used instead of light.
 - (ii) In plant cells _____ are present for the preparation of food.
 - (iii) The outer boundary of a plant cell is called _____.
 - (iv) In the nucleus, for the transfer of genetic characters _____ are present.
 - (v) Proteins are prepared in _____.
 - (vi) In eukaryotic cell nucleus is bounded by _____.
 - (vii) In crossing over _____ are exchanged in homologous chromosomes.
 - (viii) Synapsis is a phase/condition during meiosis in which _____ of homologous chromosomes takes place.
 - (ix) The basic unit of nerve tissue is _____.
 - (x) Water and dissolved minerals are transported by _____ from roots to leaves.
2. **Write whether the statement is "true" or "false" and correct the statement if it is false.**
 - (i) First microscope was invented by schwann.
 - (ii) Inside the Golgi bodies infoldings are Present which are called cristae.
 - (iii) The function of ribosomes is to prepare fats.
 - (iv) Mesophyll tissues are found in animals.
 - (v) The fruit of *Brassica* is called siliqua.
 - (vi) In winters, frogs cannot maintain the temperature of their bodies. So they are called warm blooded animals.

3. Each question is followed by four options.

Encircle the correct answer.

- (i) With the help of electron microscope object could be seen how much larger than its original size.
- (a) One lake times more.
 - (b) Two and half lake times more.
 - (c) Eighteen lakes times more.
 - (d) Twenty lakes times more.
- (ii) The term "cell" was first time used by.
- (a) Schleiden
 - (b) Schwann
 - (c) J. Purkindi
 - (d) Robert Hook
- (iii) The organelle, which provides energy to the cell is.
- (a) Mitochondria
 - (b) Golgi bodies
 - (c) Endoplasmic reticulum
 - (d) Plastids
- (iv) In side the nucleus, nucleoli and granular matter is.
- (a) Cytoplasm
 - (b) Protoplasm
 - (c) Nucleo plasm
 - (d) Cell sap
- (v) A network of channels extending from cell membrane to nuclear membrane is called
- (a) Centriole
 - (b) Vacuoles
 - (c) Endoplasmic reticulum
 - (d) Golgi bodies
- (vi) Which organelle prepares protein?
- (a) Ribosomes
 - (b) Vacuole
 - (c) Golgi bodies
 - (d) Centrosomes
- (vii) Incrossing over exchange takes place between:
- (a) Mitochondria
 - (b) Cytoplasm
 - (c) Homologus chromosomes
 - (d) Golgi bodies

(viii) *Amoeba* moves with the help of

- (a) Cilia
- (b) Pseudopodia
- (c) Flagella
- (d) Does not move

(ix) In the internal structure of *Brassica* root

from outside to inside the arrangement of first three layers is.

- (a) Endodermis, Cortex, Epidermis
- (b) Cortex, Endodermis, Epidermis
- (c) Epidermis, Cortex, Endodermis
- (d) Cortex, Endodermis, pericycle

(x) Lemina of leaf is called.

- (a) Lower stalk like part
- (b) Upper broad green part
- (c) The edges of mature leaves
- (d) Midrib of leaf

(xi) The nervous tissues has the ability to

- (a) Contract and relax
- (b) Transmit the nerve impulses
- (c) Prepare secretions
- (d) Provide energy

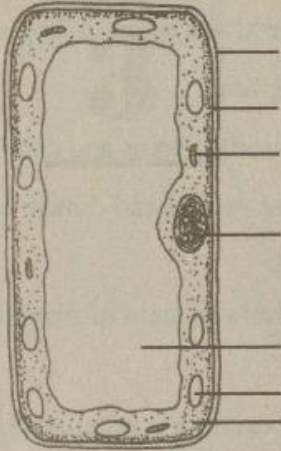
4. Write short answers of the following questions.

- (i) What do you know about cell theory.
- (ii) What is the difference is between electron and compound microscope.
- (iii) Give three differences in meiosis and mitosis.
- (iv) Describe the importance of meiosis.
- (v) Compare prokaryotic and eukaryotic cell in three lines.
- (vi) What is the function of mitochondria and Golgi bodies in the cell?
- (vii) Differentiate between simple and compound tissues?
- (viii) Why photosynthetic tissues are not found in animals and muscle tissues in plants?

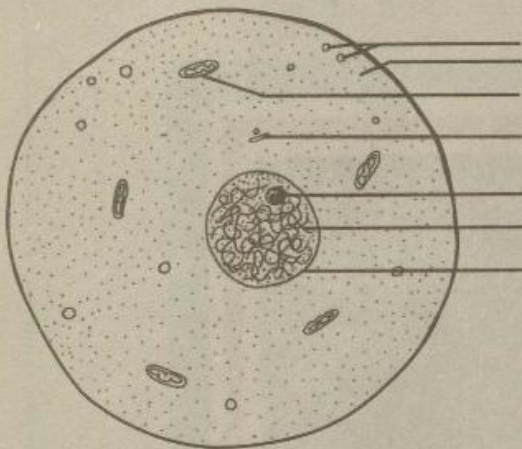
- (ix) What do you know about hibernation?
 (x) Why there is labour of division in different organs of the body of frog?

5. Label the diagrams.

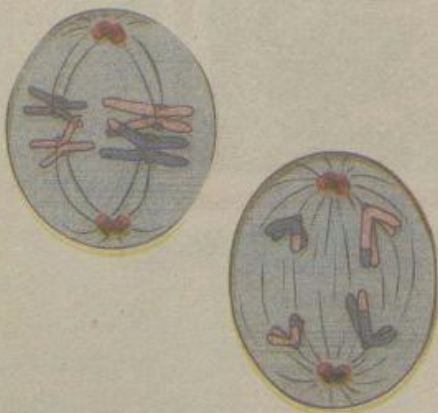
- (i) Label the given parts.



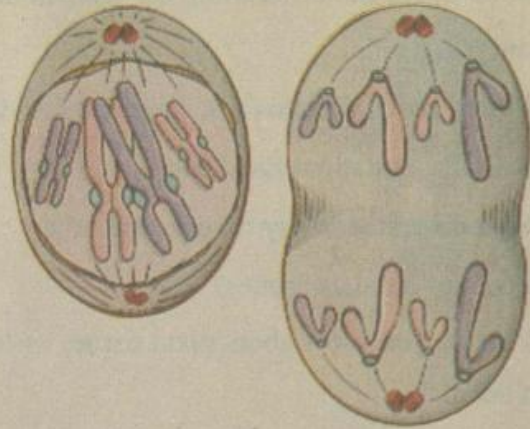
- (ii) Write the names of labelled parts.



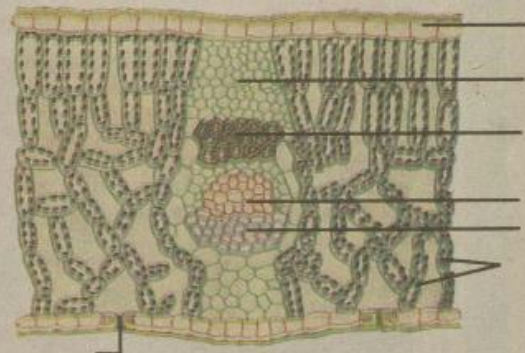
- (iii) Which stages of meiosis are shown in the given diagrams?



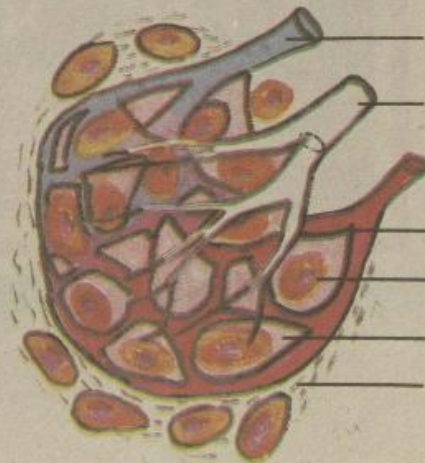
- (iv) Which division and phases are shown in the diagram.



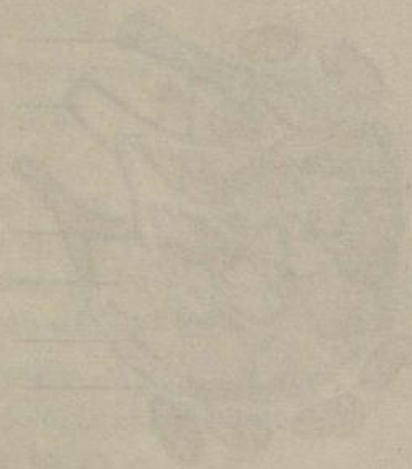
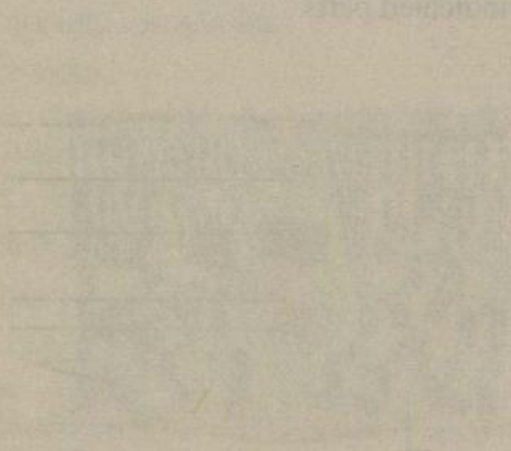
- (v) Whose internal structure is shown in the diagram of *Brassica* plant. Label the indicated parts.



- (vi) Label the diagram.

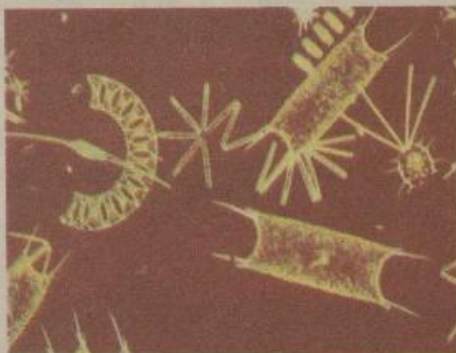


6. Describe different organelles and their function in the plant cell.
7. Write down the differences between animal and plant cells.
8. Which division, mitosis or meiosis provides bases for mutations and how?
9. What do you mean by tissues, write the details of animals tissues?
10. What do you know about plant tissue, write in details?
11. Describe the structure of *Amoeba* with the help of diagram.
12. Give an illustrated account of root of mustard plant.
13. What is the role of stem of mustard plant. Draw its labelled transverse section?
14. Describe the types of respiration in frog.
15. Discuss the digestive system of frog with the help of diagram?
16. (i) Define the arteries, veins and capillaries, (ii) Describe the ventral and dorsal side of the frog's heart.
17. Explain the arterial system of frog, supporting with diagram.
18. Write a note on excretory system of frog with the help of diagram.



Section
3

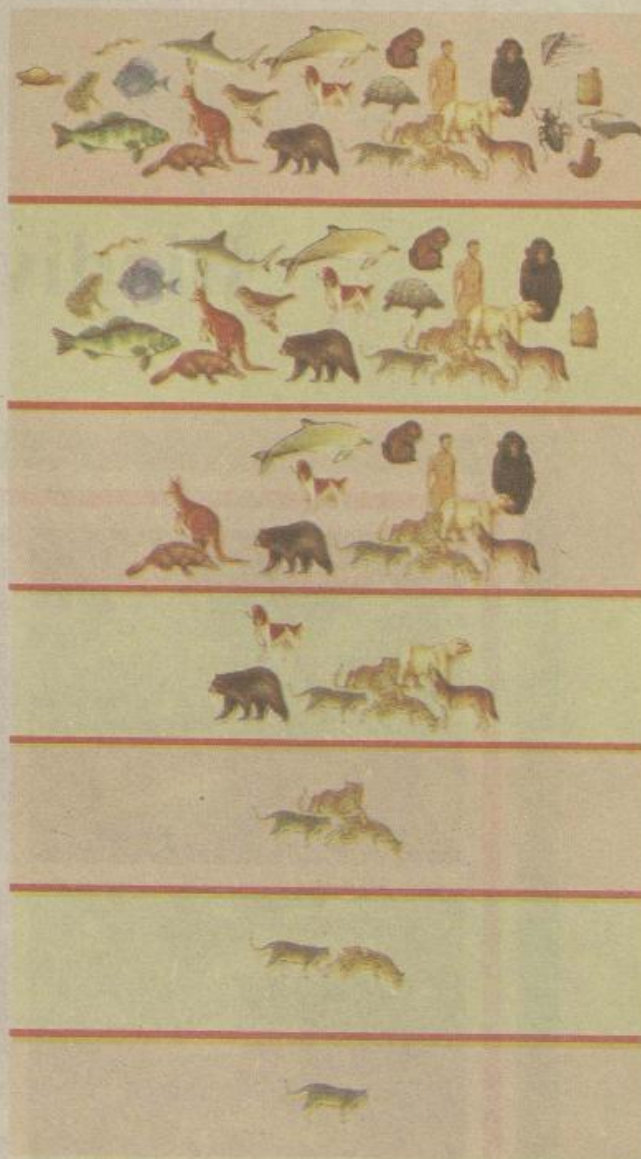
Biodiversity



CLASSIFICATION OF LIVING ORGANISMS

In this chapter you will learn:

- Definition, aims and objectives and basis (especially role of homologous organs) of classification of living organisms.
- Explanation of 'species' and order of units of classification.
- Two-kingdom and five-kingdom systems of classification
- Distinguishing characters of each kingdom and names of major groups of each kingdom.
- Binomial nomenclature-its rules and significance.
- Biological classification of some organisms.



Thousands of different kinds of organisms exist on the planet of earth. Some of the organisms are distinctly different from one another and share only a few common characteristics, others resemble more with each other and show only a few differences while some are even identical. It is necessary that organisms are classified and have scientific names so that an organism can be properly referred to when it is studied or experimented upon. **Classification** is the arrangement of organisms into

groups and sub-groups. There is a great diversity of life. About 2 million species of animals and 0.5 million species of plants have been discovered so far, and their number is increasing day by day. Every hour a new species is being added to the existing list. Some biologists estimate that about three times the number of known species are yet to be discovered. According to '**Darwin's Theory of Common Descent**', the organisms having common ancestry in the near past would resemble one another very closely, while those having more distant common ancestry would show more differences. Organisms should, therefore, be classified in a way that indicates their interrelationships. Organisms resembling one another more are placed in the same group while those showing more differences are put in different groups. This type of grouping is called '**evolutionary taxonomy**'. More and more closely related organisms show more similarities in their structure and embryology.

3.1 Basis and Aims of Classification

Classification is based on such features or characters that are similar in one kind of organisms and different in different kinds of organisms. The characters which can be used in classification include external morphology, internal morphology (anatomy), physiology, cell structure, especially the number of chromosomes and chemical composition (especially of proteins), and embryology. These characters are helpful in studying **intra-specific** (within the same species) as well as **inter-specific** (between different species) differences.

Fruits of all plants, whether sweet or sour, small and dry or large and fleshy, are homologous structures because they all develop from ovary of flower and have common origin. On the other hand, wings of an insect and a bird, despite performing same function, are not homologous because their origin is different. Similarly green leaf of a moss and that of any vascular plant are not homologous. Such organs that are similar in function but different in basic structure are called **analogous organs**.

Occurrence of some common characters in different organisms indicate their common ancestral origin. This similarity because of common ancestral origin is called **homology**. For example, arm of a monkey, flipper of a whale and wing of a bat show homology. Apparently they do not look alike but their basic internal structure (arrangement of bones and muscles) is almost similar. Such organs which have same basic internal structure and embryonic development are called **homologous organs**. On the basis of this homology, we can say that monkey, whale and bat had common ancestor, and are thus placed in the same large group "**Vertebrata**". Homology is, therefore, very important basis of classification.

Keeping in view the above facts, main objectives of classification seem to

1. determine similarities and differences between different organisms.
2. arrange organisms according to similarities and differences.
3. identify the organisms on the basis of their structure and other prominent features and study them systematically and logically.
4. find out inter-relationships of organisms.

Aristotle was first to classify animals on the basis of similarities. Later on Theophrastus classified the plants. Modern taxonomy however, started with a new system of classification proposed by a Swedish biologist Carolus Linnaeus (1707-1778)

3.2 Units of Classification

Basic unit or category of classification is **species** (plural species). A species can be defined as 'a group of organisms that can breed with one another in nature and produce fertile offspring. All members of a species have same number of chromosomes in their cells and also have many other characters in common. For example, all mustard plants belong to same species and all human beings belong to another species. Different species differ from one another and generally cannot interbreed freely with one another in nature.

A donkey and a mare (female horse) can interbreed with one another to produce a mule yet they belong to two different species because mule does not possess the ability to produce offspring.

Different but closely related species are grouped together into a larger category known as **genus** (Plural: genera). For example, *Brassica* is a genus which includes several species such as mustard, cabbage and turnip. Similarly genus *Felis* includes different species such as lion, tiger and cat. In the same way many closely related genera are grouped into a still higher category known as a **family**, families are grouped into an **order**, orders are put together into a **class** and closely related classes are grouped into a **phylum** (plural: **phyla**), which are also called **divisions** among plants, fungi and algae. The phyla or divisions are in turn, grouped into **kingdom**.

Each rank of classification is called **taxon** (plural **taxa**); hence the branch dealing with classification is called **taxonomy**.

In this system of classification organisms showing increasingly more and more similarities in their structure, form and embryology are placed together in smaller and smaller taxonomic categories.

Figure 3.1 depicts, in ascending order, the units of classification of human being.

The biological classification of mustard plant is given below.

Common name : Mustard

Kingdom	Plantae
Division (Phylum)	Anthophyta (Tracheophyta)
Class	Dicotyledonae
Order	Capparales
Family	Brassicaceae
Genus	<i>Brassica</i>
Species	<i>Brassica campestris</i> (Scientific name of mustard plant)

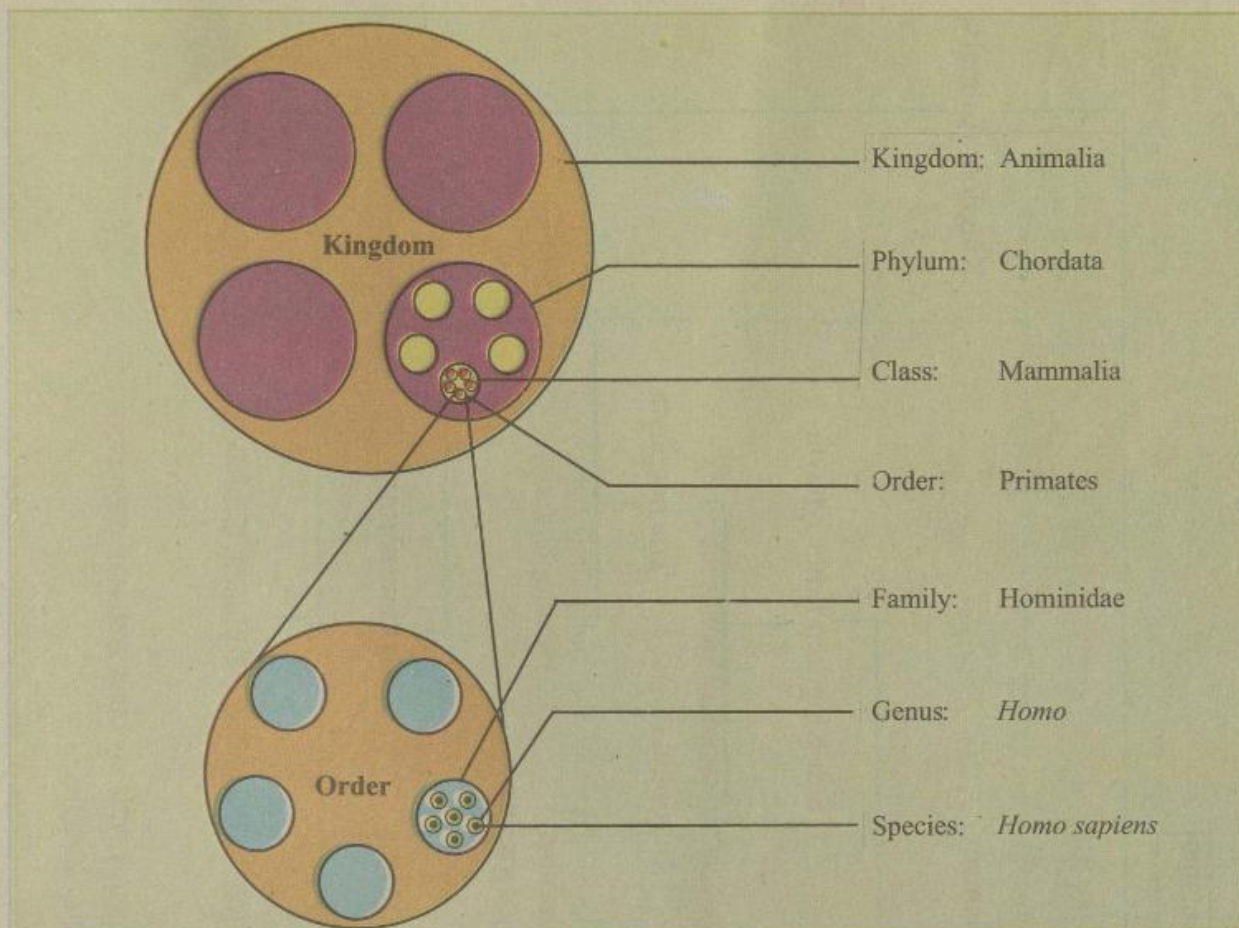


Fig. 3.1 Biological classification of human being

3.3 Kingdoms of Living Organisms

Classification is not rigid or static, nor has only one system of classification been followed; rather it is dynamic. Whenever any new information becomes available, it is incorporated. Therefore, many systems of classification have been used. Accordingly, living things are classified into two to five kingdoms. It has been traditional to have major divisions of life and to assign every living organism to any of such divisions.

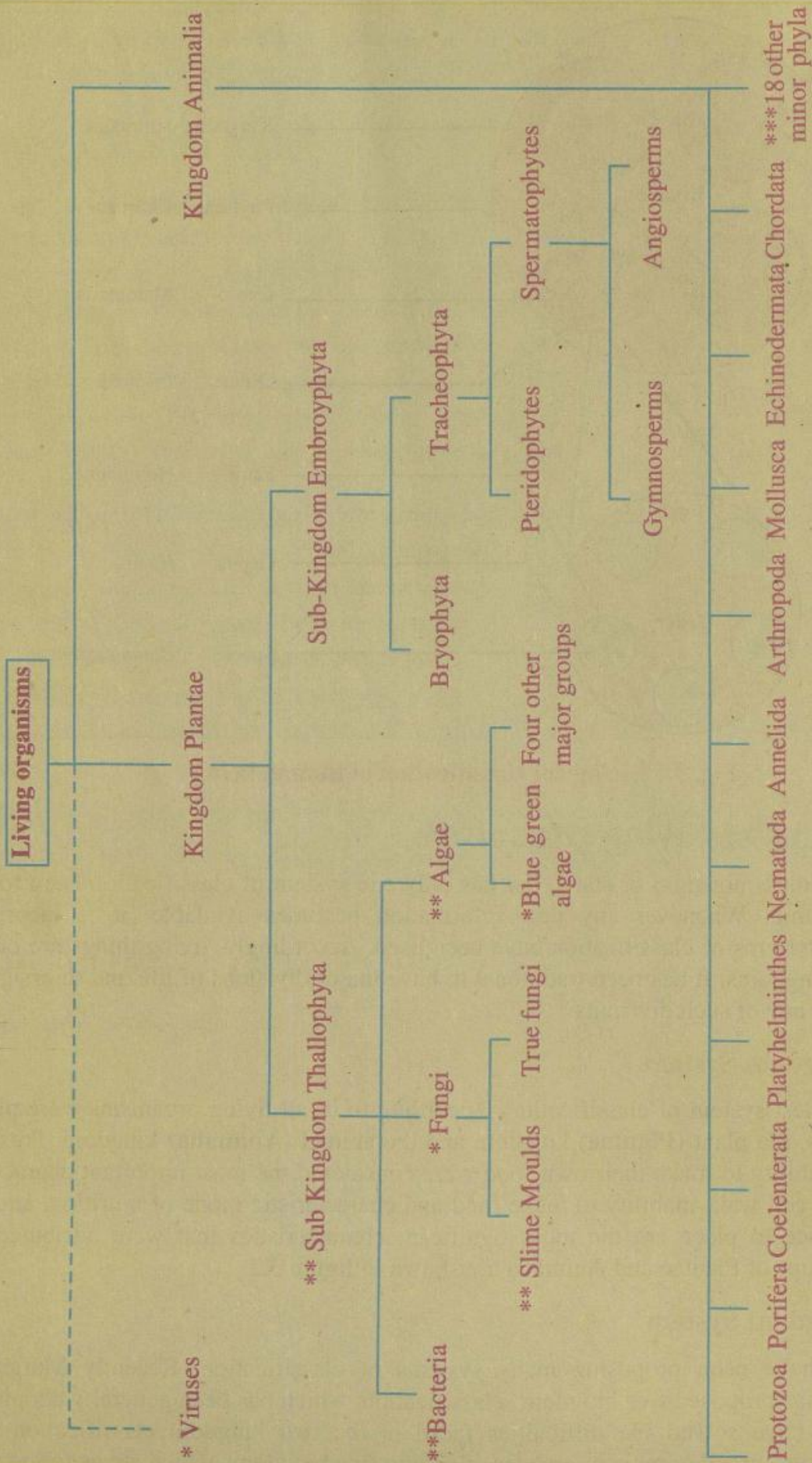
3.3.1 Two-Kingdom System

It is the oldest system of classification. According to it, all living organisms were placed in just two kingdoms, the plant (**Plantae**) kingdom and the animal (**Animalia**) kingdom. Presence of cell wall and the ability to make their own food were considered the most important characteristics of plants. Lack of cell wall, inability to make food and characteristic mode of nutrition, and ability to move from place to place are the most significant characteristics that were attributed to the animals. Main groups of Plantae and Animalia are shown in figure 3.2.

3.3.2 Five-Kingdom System

Scientists have been proposing many systems of classification. Recently Margulis and Schwartz (1982) has proposed five kingdom classification, which has been generally adopted. This system claims to have solved the difficulties faced in the two kingdom classification system. According to this system, all organisms are classified into five kingdoms which are as follows:

Figure 3.2 The Two-kingdom system of classification

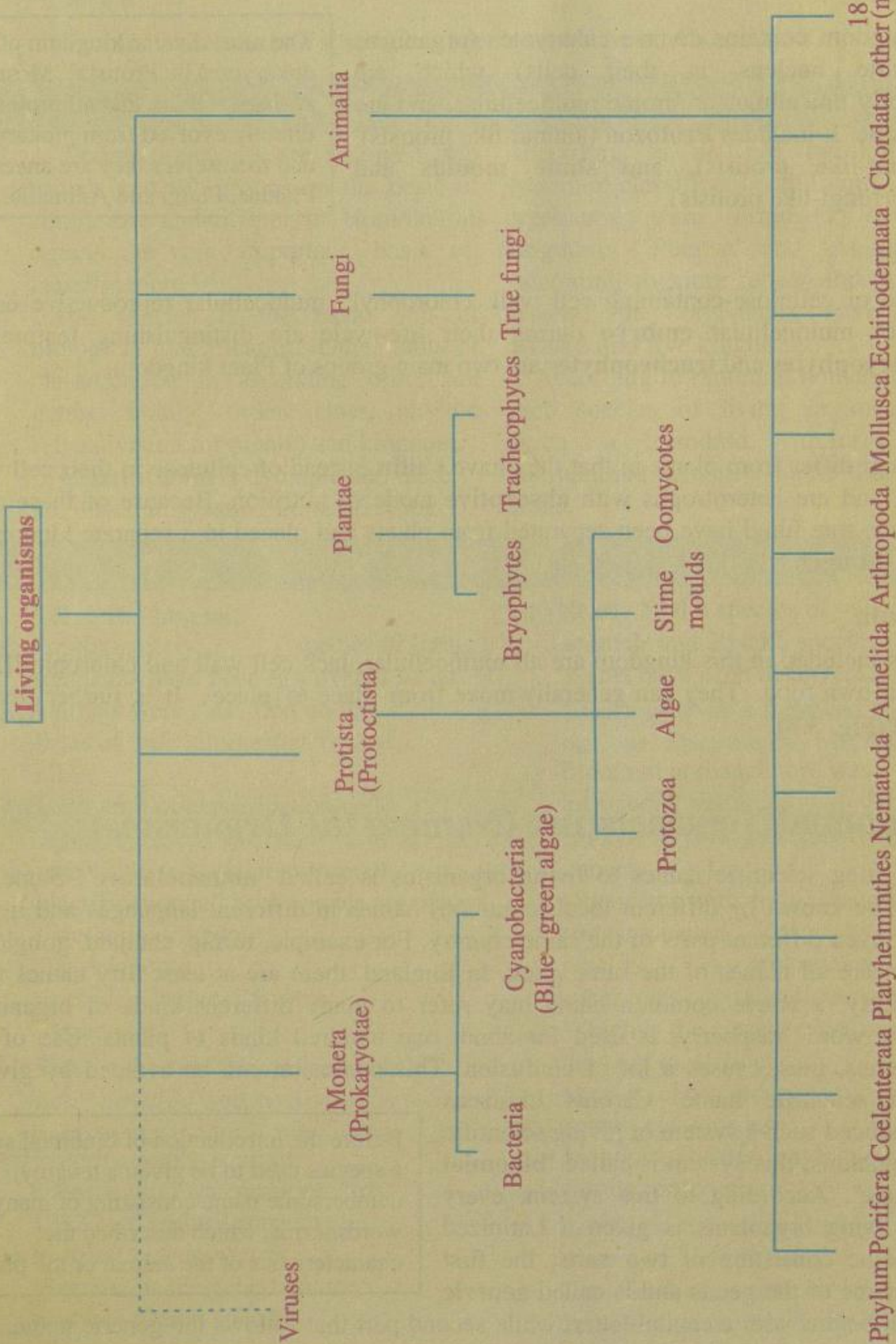


* Viruses, because of their unique characteristics, cannot be grouped together with any other groups of organisms.

** Their classification is different according to five-kingdom system of classification

*** These minor phyla are not described in this textbook.

Figure 3.3 The five-kingdom system of classification



1. Monera or Prokaryotae

All prokaryotes (organisms which lack definite nucleus in their cells) have been grouped together in the kingdom Monera. It includes the **Bacteria**, and **Cyanobacteria** or **blue-green algae**.

2. Protista

This kingdom contains diverse eukaryotes (organisms with definite nucleus in their cells) which are predominantly unicellular or simple multicellular, and are mostly aquatic. It includes **Protozoa** (animal-like protists), **algae** (plant-like protists), and **slime moulds** and **oomycetes** (fungi-like protists).

The most diverse kingdom of eukaryotes is 'Protista'. Most biologists think that all protists directly evolved from prokaryotes, and themselves they are ancestors of Plantae, Fungi and Animalia.

3. Plantae

Presence of cellulose-containing cell wall, chlorophyll, multicellular reproductive organs and formation of multicellular **embryo** during their life-cycle are distinguishing features of this kingdom. **Bryophytes** and **tracheophytes** are two main groups of Plant kingdom.

4. Fungi

True fungi differ from plants in that they have **chitin** instead of cellulose in their cell wall, lack chlorophyll and are heterotrophs with **absorptive** mode of nutrition. Because of these and some other reasons, true fungi have been separated from plants and placed in a separate kingdom of their own called '**Fungi**'.

5. Animalia

Animals included in this kingdom are all multicellular, lack cell wall and chlorophyll, can not prepare their own food. They can generally move from place to place. It is further divided into many phyla (Fig. 3.3).

3.4 Binomial Nomenclature (Naming the Organisms)

Assigning scientific names to living organisms is called '**nomenclature**'. Same plant or animal may be known by different local (common) names in different languages and in different countries or even different parts of the same country. For example, turnip, shaljam, gongloo, thipar and gogroon are all names of the same plant. In England, there are at least fifty names for pansy plant. Similarly, a single common name may refer to many different kinds of organisms. For example, the word 'raspberry', is used for about one hundred kinds of plants. Use of local or common names, thus, causes a lot of confusion. This confusion can be avoided by giving each organism a scientific name. Carolus Linnaeus (1753) introduced such a system of giving scientific names to organisms; this system is called '**binomial nomenclature**'. According to this system, every species of living organisms is given a Latinized scientific name consisting of two parts; the first part is the name of the genus and is called **generic name** which begins with a capital letter, while second part that follows the generic name, specifies

Before the introduction of binomial system, a species used to be given a lengthy, cumbersome name consisting of many words/terms, which described the characteristics of the animal or the plant.

the species and begins with a lower case letter. For example, *Brassica campestris* is scientific name for mustard plant; *Brassica* is the generic name whereas *campestris* specifies the species when used after the generic name. Scientific name for rose plant is *Rosa indica*, for frog *Rana tigrina*, and for human being it is *Homo sapiens*. It is traditional to write the species name in italics or else underline the two parts separately.

Binomial nomenclature system has been adopted by all taxonomists.

KEY POINTS

1. Living organisms are arranged into groups and sub-groups on the basis of similarities and differences. Homologous organs are very important basis of classification.
 2. The species is the basic unit of biological classification. Other units of classification in ascending order are genus, family, order, class, phylum (also division for plants) and kingdom.
 3. Classification is dynamic and there are different system of classification.
- According to an old two-kingdom system of classification all living organisms were arranged in two kingdoms ('Plantae' and 'Animalia'). According to more recent and popular system, the organisms have been divided into five kingdoms.
4. According to binomial nomenclature, each species of living organisms is given a standard, uniform and international scientific name that is its alone.

QUESTIONS

1. Fill in the blanks.

- (i) Approximately _____ species of living organisms have been discovered so far.
- (ii) Animals were classified on the basis of their similarities first of all by _____.
- (iii) Basic unit of classification is _____.
- (iv) According to popular system of classification, all prokaryotes are placed together in kingdom _____.
- (v) The kingdom _____ includes the most diverse organisms.

2. Write whether the statement is 'true' or 'false' and write the correct statement if it is false.

- (i) Five-kingdom system of classification was proposed in 1982 by Carolus Linnaeus.
- (ii) In *Brassica campestris*, *Brassica* is the generic name and *campestris* specific.

- (iii) Nearly 5 lakh species of animals and 20 lakh species of plants have been discovered so far.

3. Each question is followed by four options. Encircle the correct answer.

- (i) Binomial nomenclature was introduced by
(a) Aristotle (b) Margulis and Schwartz
(c) Linnaeus (d) Darwin
- (ii) Organisms with definite nucleus in their cells are called
(a) protists (b) prokaryotes
(c) eukaryotes (d) unicellular organisms
- (iii) Which is the correct order of units of classification?
(a) species, class, order,
(b) genus, class, order
(c) kingdom, species, phylum
(d) family, order, class

4. Define classification and describe its aims and objectives.

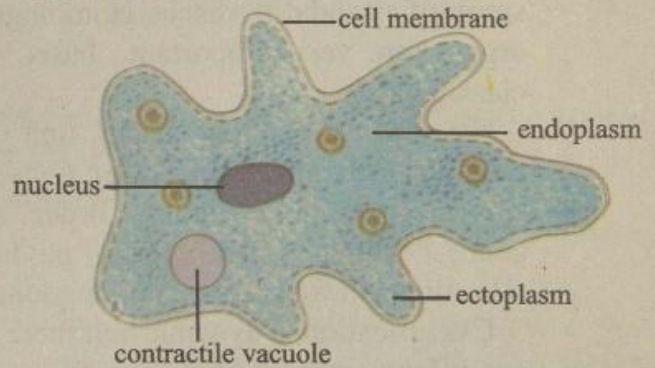
5. Explain the importance of homologous organs in biological

classification. What criteria other than homologous organs are used for classification?

6. Define the term species, and give its examples.
7. Write in correct order, the units of classification.
8. Give biological classification of human being.
9. Name five kingdoms of living organisms according to five kingdom system and give distinguishing

characteristics of each kingdom.

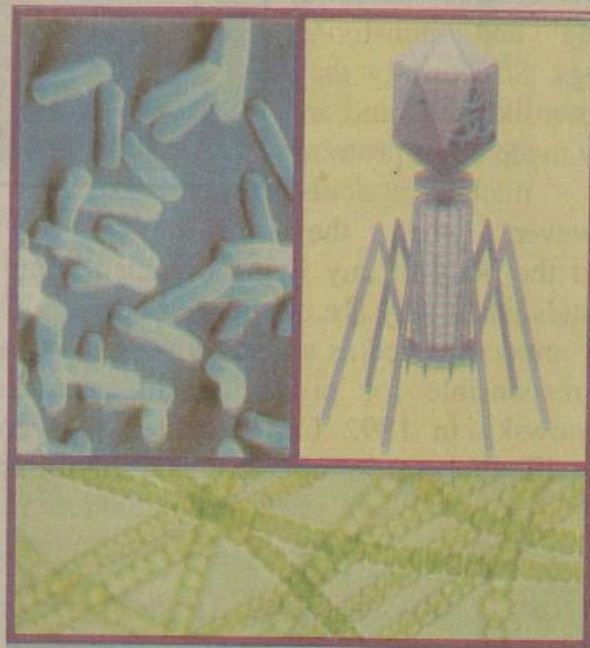
10. What is meant by 'binomial nomenclature'? Describe its rules and significance.
11. Following labelled figure represents an aquatic unicellular organism- *Amoeba*. In which group of organisms would you place it according to five kingdom system of classification? Give reasons for your answer.



VIRUSES, BACTERIA AND CYANOBACTERIA

In this chapter you will learn:

- Definition of micro-organism.
- Micro-organisms as a heterogeneous group
- Structure of viruses.
- Diseases caused by viruses.
- Structure of Bacteria.
- Advantages and disadvantages of bacteria.
- Characteristics of cyanobacteria.



A large number of living organisms are found in this world. Some of them are large and some are small. Majority of the organisms are so small that they cannot be seen with naked eyes. In order to observe them, we need some magnifying device like a light microscope or even an electron microscope. Such microscopic organisms are called micro-organisms.

Micro-organisms form a heterogeneous group which includes different kinds of organisms- viruses, bacteria, cyanobacteria, protozoa, certain algae and some fungi. On the basis of structure they range from sub-cellular to cellular for example, viruses are sub-cellular and all other microorganisms are cellular. Bacteria and cyanobacteria are prokaryotes where as algae, fungi and protozoa are eukaryotes. According to the mode of nutrition algae are autotrophic while fungi and protozoa are heterotrophic. Thus different microorganisms vary in their structure and mode of nutrition. In this chapter we will study about viruses, bacteria and cyanobacteria. Due to peculiar characteristics of viruses, they are placed in a separate group where as bacteria and cyanobacteria, being prokaryotes, are included in kingdom Monera (see chapter 3).

4.1 Viruses

Virus is a Latin word which means "poison". Viruses are so small that they cannot be observed with light microscope but can only be seen with electron microscope. They have characteristics of both living and non-living things. Structurally they are not like cells and are only made up of proteins and nucleic acids.

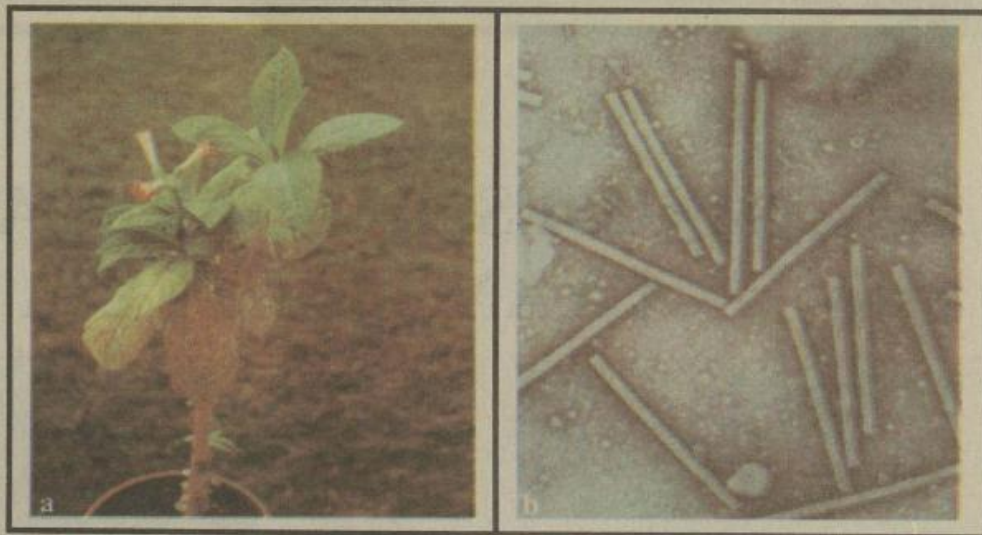


Fig. 4.1 (a) Tobacco plant infected with virus (b) Ultra-structure of virus

However, when they enter the body of any living organism, they reproduce there like living organism. They look like crystals when they are out of the body of a living organism and also do not reproduce. That is why they are considered as a link between living and non-living things. All viruses are parasites and may be responsible for producing different diseases in their hosts. Viruses were discovered by Iwanowsky in 1892 from infected tobacco leaves. In 1935 W.M. Stanley isolated viruses in crystalline form from infected leaves of tobacco and observed them under electron microscope. (Fig. 4.1)

4.1.1 Size and Shape of Viruses

Viruses are of different sizes, ranging from $0.01\mu\text{m}$ to $0.3\mu\text{m}$ (μm is Micrometer = $1/10,00,000$ meter). Viruses vary in shape; some are rounded, few are rod shaped, few polyhedral while some viruses look like tadpoles (Fig. 4.2)

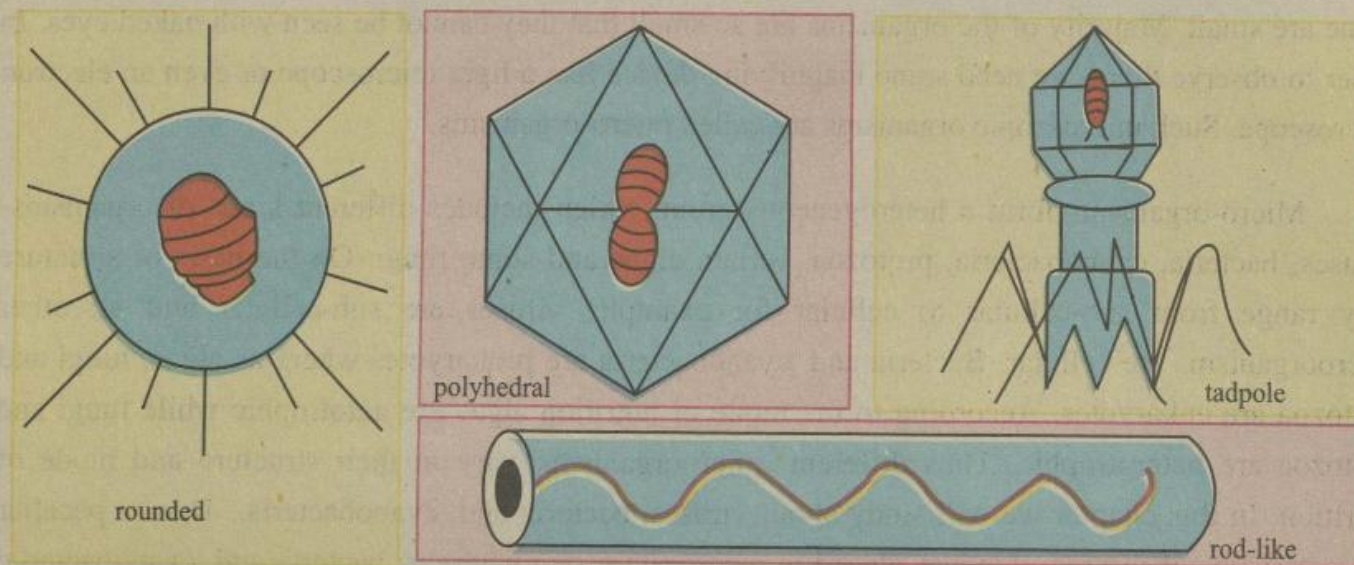


Fig. 4.2 Different shapes of viruses

4.1.2 Structure of Virus

Viruses are bio-chemically alike. They differ in their shapes but all are made up of only two parts, an outer “coat”, and an inner “core”. The core is made up of DNA or RNA (never both) and the coat is composed of protein. The outer coat determines the shape of viruses e.g., in bacteriophage (virus that lives in bacteria) protein coat consists of two parts, head and tail. DNA is present in the head region but the tail has only protein. Most of the animal viruses contain DNA whereas plants viruses have RNA core. (Fig 4.3)

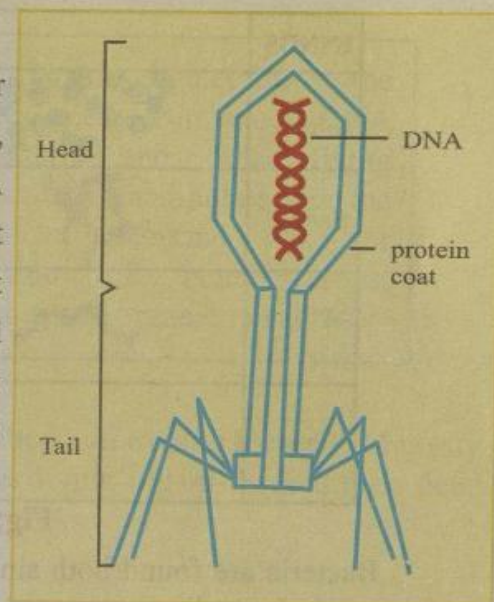


Fig.4.3, Structure of virus (a bacteriophage)

4.1.3 Viral Diseases

Viruses produce many diseases in plants and animals. Ring spot in different plants, yellow in sugar beet and mosaic disease in tobacco, potato, tomato, bean and cabbage are the various viral diseases of plants.

Mouth and foot disease in cattle and cowpox in horses, buffalo and cows are caused by viruses. In human beings, viruses produce common cold, influenza, smallpox, yellow fever, polio, infectious hepatitis, cancer and AIDS.

Viruses in living organisms are transmitted in a variety of ways e.g., through droplets produced on coughing and sneezing, through contact, by air, contaminated water and food, through insects, by reuse of already used syringes and by un-sterilized surgery equipments.

4.2 Bacteria

Bacteria are most widely distributed organisms. These are unicellular micro-organisms. Leeuwenhoek discovered bacteria in 1697 for the first time. Later, Louis Pasteur and Robert Koch worked on them. This was a milestone in the history of biology and medicine. They discovered that bacteria produce many diseases in man and animals. Bacteria (singular; bacterium) range from 1 μm to 10 μm in length and from 0.2 μm to 1 μm in width and can be observed under light microscope.

Bacteria are found everywhere; in air, water, living and dead bodies of organisms and even in glaciers and hot springs.

4.2.1 Kinds of Bacteria

On the basis of shape and form, bacteria are of four types (Fig; 4.4).

- 1 Rounded _____ Cocci (singular; coccus)
- 2 Rod-like _____ Bacilli (singular; bacillus)
- 3 Spiral shaped _____ Spirilla (singular; spirillum)
- 4 Comma-shaped _____ Vibrios (singular; vibrio)

KINDS	SHAPES
Cocci	
Bacilli	
Spirilla	
Vibrios	

Fig; 4.4 Different shapes of bacteria

Bacteria are found both singly and in colonies. Cocci bacteria may occur in groups of two or four, or in irregular groups and even in the form of long beads. Bacilli are found singly or may join end to end to form long threads. Spirilla and Vibrios however, occur singly.

4.2.2 Structure of Bacteria

Bacteria are single celled prokaryotic organism. Bacterial cell is surrounded by a cell wall which is composed of carbohydrates and amino acids. A few bacteria have an additional slime capsule around their cell wall, which protect them and prevent them from drying. Generally the capsule is found in parasitic bacteria. Cell membrane is present inside the cell wall. The mitochondria and other membrane bounded organelles are absent. Enzymes needed for respiration are found on the invaginations of cell membrane. Cytoplasm contains ribosomes. Nucleus is absent in bacterium. However, only a single large circular chromosome made up of DNA, is present, which is surrounded by a clear zone of cytoplasm. It is called a nucleoid. This is not bounded by a nuclear membrane. (Fig: 4.5)

Three thousand million bacteria are present in one milli litre of fresh milk and two and half million bacteria are present in one gram of fertile soil.

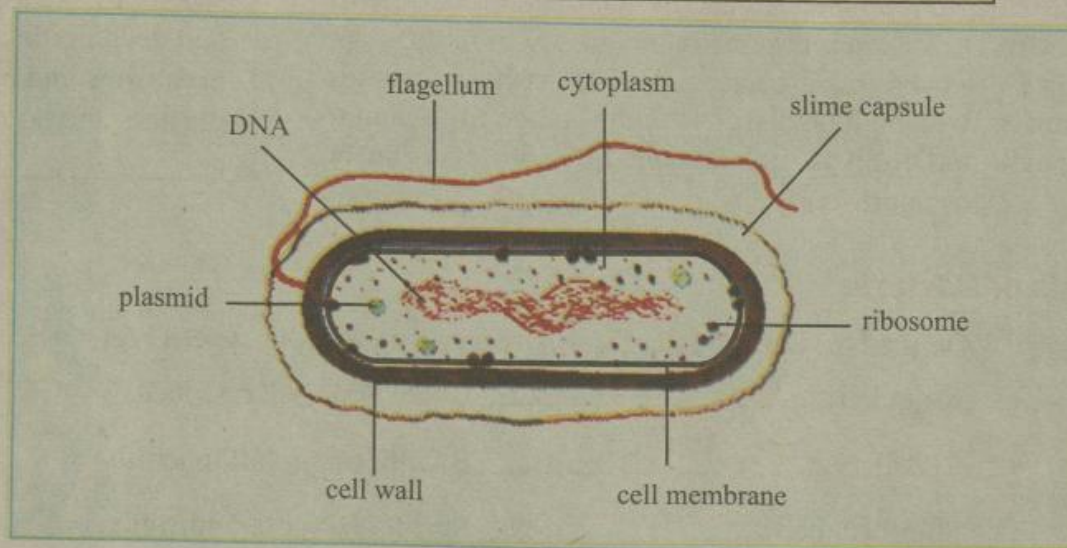


Fig. 4.5 Structure of bacterium

In addition to main bacterial DNA small circular molecules of DNA called plasmids are also present. Plasmids play an important role in transmission of some hereditary characteristics. These are also used in genetic engineering. Motile (which can move) bacteria have one or more thread like flagella (singular; flagellum), which help them in their locomotion. Non-motile bacteria lack flagella.

Genetic engineering is the scientific method in which DNA of bacteria and other living organisms are manipulated for the benefit of mankind e.g. for production of better crops, medicines and organic materials.

Some Bacteria can manufacture their own food and are called autotrophic bacteria. Majority of bacteria are unable to make their food and obtain it from other living organisms and their dead bodies; they are known as heterotrophic bacteria.

Autotrophic bacteria are of two types:

(i) Photosynthetic bacteria

Photosynthetic bacteria like all green plants manufacture their own food by photosynthesis. However, chemical structure of their chlorophyll is different from plant chlorophyll.

(ii) Chemosynthetic bacteria

Chemosynthetic bacteria get energy by oxidizing compounds of sulphur, nitrogen and other inorganic substances. This process is called chemosynthesis.

Heterotrophic bacteria include (i) Parasitic bacteria and Saprotrophic bacteria.

i) Parasitic bacteria

The bacteria which live on other living organisms for their nutrition and survival are called parasitic bacteria. The parasitic bacteria also cause diseases in plants or animals are known as pathogenic bacteria.

ii) Saprotrophic bacteria

Bacteria which obtain their food from dead organic matter are known as saprotrophic bacteria.

Practical Work: Study of prepared slide of Bacteria.

- 1 Set a prepared slide of bacteria under a microscope.
- 2 Focus it under low power and observe.
- 3 What did you observe?
- 4 Now focus the slide under high power and observe.

You will observe bacteria of different shapes on the slide. Draw diagrams of these bacteria.

Bacteria that need oxygen for respiration are called aerobic bacteria, while those, which do not require oxygen for respiration, are called anaerobic bacteria. Oxygen may rather be injurious for anaerobic bacterium.

Bacteria need food, water and suitable temperature for their growth. Some bacteria, especially bacilli under unfavourable conditions form endospores inside their cell wall. Endospore is a tiny structure containing DNA, small portion of cytoplasm and a tough protective coat and can resist unfavourable conditions by remaining dormant for many years. When conditions become favourable, the endospore develops into a new bacterium.

Generally a bacterium reproduces asexually by simple division into two identical bacteria. Some bacteria also reproduce sexually.

One bacterium divides into two within twenty minutes.

Bacteria, like viruses are transferred from one living organisms to another through different agencies like droplets, touch, contaminated water and food, insects and other animals.

Importance of Bacteria

It is generally a false impression that bacteria are harmful organisms. There are number of bacteria which are not only beneficial for mankind but are also essential for living system.

Beneficial Bacteria

- 1 Bacteria are of great ecological importance. These, along with fungi, help to decompose dead organisms and their refuse into simpler substances replenishing the raw materials in the soil and atmosphere and can thus purify the environment.
- 2 Bacteria can add nitrogenous compounds in soil thus improving its fertility. These bacteria are called nitrogen fixing bacteria. Another kind of bacteria live in the soil called nitrifying bacteria which convert ammonia into nitrite and then to nitrate, enhancing the amount of nitrogen in the soil.
- 3 Bacteria are also used for industrial and commercial purposes, such as:
(i) in manufacturing butter, cheese and yogurt.
(ii) in processing of commercial fibres, leather, coffee, tobacco and vinegar.
- 4 Bacteria synthesize cellulase enzyme in the stomach of herbivore animals which helps in the digestion of food. Some bacteria also synthesize vitamin "B" and "K" in the large intestine of man and other mammals.
- 5 Recently the use of bacteria as bio-insecticides has become popular.

Harmful Bacteria

Bacterial decomposition on one hand is beneficial but on the other hand causes damage to food, wood, clothes and other things. Denitrifying bacteria in soil, reduce the amount of nitrogen in soil thus damaging soil fertility. Many bacteria are harmful and are responsible for many diseases in plants, such as canker disease in citrus fruits; rot and fire blight in peach, pear and apple; and potatoscab in potato.

In animal like cattle bacteria are responsible for T.B. and anthrax. Bacteria also cause many diseases in man like T. B., whooping cough, diphtheria, typhoid, pneumonia, tetanus, plague, bacterial dysentery, cholera, leprosy etc.

Whooping cough, diphtheria, T.B. and Pneumonia causing bacteria spread from one person to other person through sneezes and cough droplets released in air. Bacteria causing Typhoid and Cholera are transmitted from one organism to another through contaminated water and food. Plague and bacterial dysentery spread through vectors like flies and animals.

4.3 Cyanobacteria

Cyanobacteria are also known as blue green algae. They are considered as the simplest living organisms with ability to manufacture their own food by photosynthesis. Structurally they resemble bacteria. Bacteria and cyanobacteria are prokaryotes.

Generally cyanobacteria are found in moist places (trunks of trees, rocks and soil), fresh water and oceans. Some of them are symbionts and some are epiphytes.

Cyanobacteria are usually unicellular and solitary but some are colonial or filamentous. Each filament consists of many cells which are attached with each other. Cyanobacteria always have a protective mucilagenous sheath around their cell wall. (Fig., 4.6)

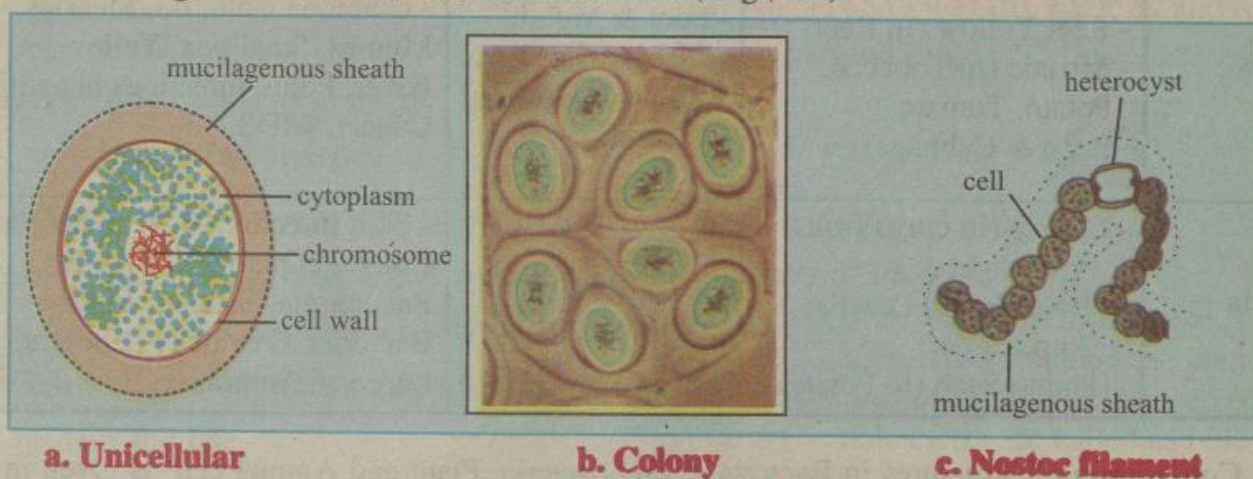


Figure 4.6 Blue green algae.

Like bacteria, some cyanobacteria also have ability to fix nitrogen of atmosphere in their specialized cells called heterocysts. Heterocysts are large cells with thick cell wall as compared to other cells. In addition to chlorophyll, cyanobacteria also contain blue green pigment called phycocyanin, due to which these are called as blue green algae. Only asexual reproduction occurs in Cyanobacteria by cell division, spore formation and fragmentation. *Nostoc* and *Anabaena* are common examples.

Nitrogen fixing blue green algae like *Nostoc* and *Anabaena* are grown in rice fields to increase fertility of soil.

KEY POINTS

1. Micro-organisms are of different kinds of small organisms which cannot be seen with naked eyes but can be viewed only with microscope.
2. Viruses can only be seen with electron microscope. These are sub-cellular organisms having characteristics of both living and non-living things.
3. Virus consists of two parts - inner core and an outer coat. Inner core is made up of DNA or RNA and outer coat of protein.
4. Bacteria are of four kinds (rounded, rod-like, spring like and comma shape) on the basis of their morphology.
5. Bacterium is a unicellular organism, which has no organized nucleus. It consists of a

chromosome made up of DNA and no nucleus.

6. Most bacteria are heterotrophic i.e., they cannot synthesize their own food and some bacteria are autotrophic i.e., they manufacture their own food.

7. Bacteria are of great ecological, industrial

and commercial importance.

8 Structurally cyanobacteria resemble with bacteria. They are the simplest photosynthetic organisms also known as blue green algae.

9. Viruses and bacteria cause many diseases in plants, animals and human beings. Few diseases are given in the following table.

Micro-organisms	Diseases		
	In Plants	In animals	In human beings
Viruses	- Ring Spot - Beet Yellow (In Beet) - Mosaic (In Tobacco, Potato, Tomato, Bean & Cabbage)	- Foot & Mouth Disease (In Cow, Buffalo & Horses) - Cowpox	- Common Cold, flu, Measles, Mumps, Smallpox, Yellow Fever, Polio, Infectious hepatitis, Cancer, AIDS.
Bacteria	- Canker (In citrus fruits) - Fire Blight & Pot Diseases (In Peach, Apple, Pear) - Potato Scab (In Potato)	- T.B. & Anthrax (In Cattle)	- Skin Infection, T.B., Whooping Cough, Diphtheria, Typhoid, Pneumonia, Tetanus, Plague, Bacterial Dysentery, Cholera, Leprosy, Anthrax.

10. Comparison of Structures in Bacteria, Cyanobacteria, Plant and Animal cell is given in the following table.

Organism	Cell structures				
	Cell wall	Cell membrane	Mitochondria	Chloroplast	Organized nucleus
Bacteria	✓	✓	X	X Chlorophyll is present in the cytoplasm of some bacteria	X
Cyanobacteria	✓	✓	X	X Chlorophyll is present	X
Plant	✓	✓	✓	✓	✓
Animal	X	✓	✓	X	✓

QUESTIONS

1. Fill in the blanks

- (i) Some characteristics of viruses are like ----- as well as non living things.
- (ii) Inner core of bacteriophage is made up of ----- and outer coat is of protein.
- (iii) Polio, smallpox and measles in man are caused by -----.
- (iv) Nitrifying bacteria convert ----- of the air to increase the fertility of soil.
- (v) Typhoid, T.B., and cholera in man are caused by -----.
- (vi) Blue green algae is green due to chlorophyll and blue due to -----.

2. Indicate whether the following statements are correct or incorrect. If the statement is incorrect then write correct statement.

- (i) Cell wall of bacterium is made up of protein and fat.
- (ii) Slime capsule is present around cell wall of some bacteria.
- (iii) Those bacteria which manufacture their own food are called heterotrophic bacteria.
- (iv) Those bacteria which do not manufacture their own food are called autotrophic bacteria.
- (v) Cholera, tetanus and diphtheria are caused by viruses.
- (vi) Prokaryotes have organized nucleus.

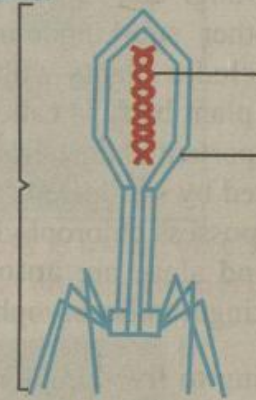
3. Four options are given for each question. Encircle the correct answer.

- (i) All viruses are
(a) free living (b) parasites
(c) saprotrophic (d) symbionts.
- (ii) Which of the following characteristic of viruses is not like that of living things.
(a) growth (b) reproduction
(c) crystals (d) respiration
- (iii) Outer coat of virus is made up of
(a) protein (b) DNA
(c) carbohydrates (d) fats
- (iv) Which of the following organisms are called decomposers?
(a) algae and virus (b) bacteria and fungi
(c) algae and fungi (d) virus

4. Write short notes

- (i) Write down three advantages of bacteria.
- (ii) Name four kinds of bacteria on the basis of shape.
- (iii) Which diseases are caused by viruses and bacteria in man? Write down the names of three diseases of each.
- (iv) Why Cyanobacteria are called as blue green algae?

5. Identify the diagram given below and label its various parts.

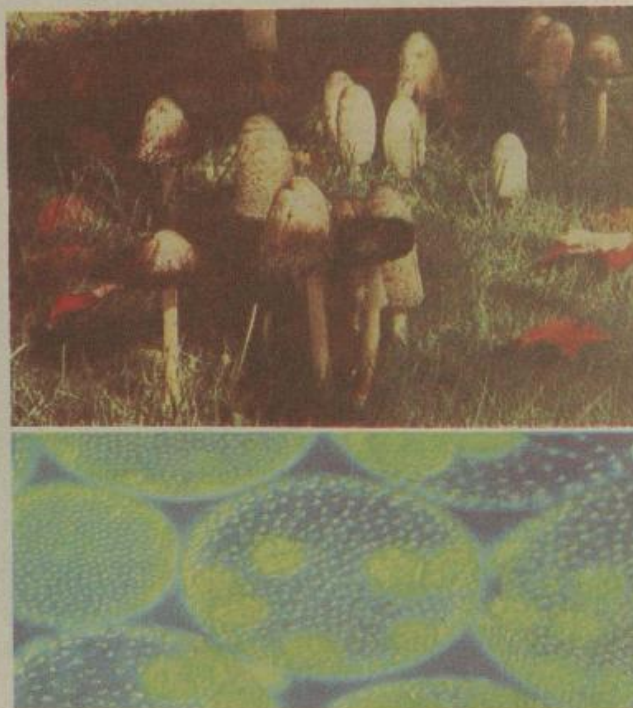


6. Describe in detail structure of a bacterial cell.
7. Do you think viruses are living things? explain.
8. Bacteria, cyanobacteria, plant and animal cell have some common as well as contrasting characteristics, explain.

FUNGI AND ALGAE

In this chapter you will learn:

- Important characteristics of fungi.
- Major groups of fungi.
structure of fungi and structure of *Rhizopus* and mushroom.
- Ecological role and economic importance of fungi.
- Important characteristics of algae.
- Names of major groups of algae and structure of *Chlamydomonas* and *Spirogyra*.
- Economic importance of algae.
- Comparison of algae, fungi and plants.



Fungi and algae are simple organisms with cell wall. According to two kingdom system of classification, fungi and algae are grouped together in sub kingdom “Thallophyta” of kingdom plantae; the other sub-kingdom of plants being “Embryophyta” (see Chapter 3, Figure 3.2). Thallophyta includes plants with simple plant body which is not differential into root, stem and leaves. Such a plant body is called **thallus**. Hence these plants are called the thallophytes. Another, rather more important characteristics of thallophytes is that their reproductive organs are unicellular and not protected by sterile cells. Fungi lack chlorophyll and cannot prepare their own organic food, whereas algae possess chlorophyll and can synthesize their own food. Thus fungi are **heterotrophic thallophytes** and algae are **autotrophic thallophytes**. All plants other than fungi and algae are placed in sub-kingdom Embryophyta. You will learn about embryophytes in next chapter.

According to five-kingdom system of classification, fungi have been separated from plants because of their cell wall features, mode of nutrition and some other reasons, and placed in a kingdom of their own-the kingdom “Fungi”. Algae, alongwith **Protozoa** and some other organism, have been placed in a new kingdom, called “**Protista**”; it includes all unicellular and simple multicellular **eukaryotes** which are mostly found in water (see Chapter 3, figure 3.3).

In this chapter, fungi and algae have been described according to popular “five-kingdoms” system of classification.

You might have observed umbrella-shaped **mushroom** emerging in a large number on dung piles (heaps of dung) during rainy season. Fluffy mass of tangled threads like structures with black dots of **molds** are also often seen growing on oranges and bread, these mushroom and molds are 'fungi'.

5.1.1 Characteristics of Fungi

Fungi are simple heterotrophic eukaryotes with absorptive mode of nutrition (i.e absorb prepared food) and cell wall made up of chitin instead of cellulose. Some fungi are **parasitic** while others are **saprotrophs**. Parasitic fungi obtain their food from other living organisms (called the hosts); many of them cause disease in many important crop plants and some attack animals and man. Saprotrophic fungi get their food from dead animals, plants, their wastes and decomposing materials. Saprotrophs secrete and pour out many digestive **enzymes** on the dead bodies which convert dead/waste organic materials into simpler substances that are absorbed by the fungus. Mushrooms and bread mold *Rhizopus* are saprophitic fungi.

Fungi may also form association, of mutual benefit, with some other organisms. Some fungi are associated with some algae to form **lichens**. Such a fungus gets the food prepared by the alga and in turn provides protection and water to the alga. The lichens are therefore **mutualists**. Mycorrhizal fungi found in association with roots of plants are also mutualists.

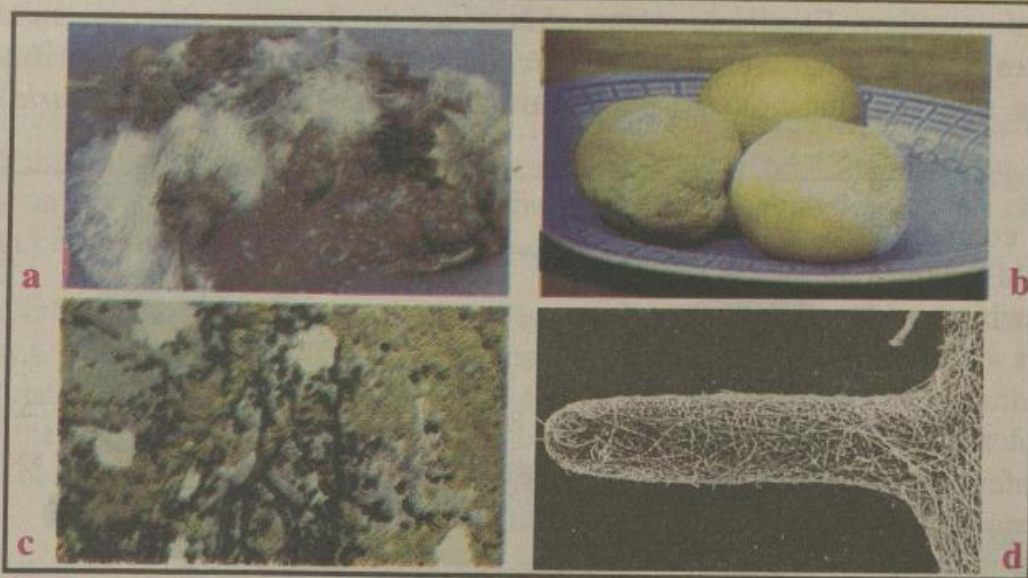


Fig. 5.1 (a) Mold growing on eatables (b) *Penicillium* growing on citrus fruit
(c) Lichens growing on rocks and tree trunks (d) Hyphae around root-mycorrhiza



(e) Nematode - eating fungus (f) Fungus garden

Fungal cell wall contain **chitin**, which is a complex carbohydrate also found in external skeleton of insects and other arthropods. Plant cell wall, on the other hand, contains cellulose. Body of a fungus is generally composed of branched, tubular threads called **hyphae** (singular hypha) which are always found in groups. A group of hyphae is called **mycelium**. Hyphae may be **septate** or **non-septate**. Septate hyphae have partitions called **septa** (singular septum), which divide the hypha into cell like chambers; each chamber having one or more nuclei. Hyphae of mushroom are septate. Non-septate hyphae lack septa and contain many nuclei in their cytoplasm. Such hyphae are called **coenocytic hyphae**, as in *Rhizopus*. Yeasts are the only unicellular fungi and do not possess mycelium.

Some ants collect fungal hyphae, mix them with pieces of leaves and form 'fungus garden'. The ants feed on fungus and also remain protected there. There is a fungus, which forms sticky loops around the soil dwelling nematodes and eats them.

In the presence of moisture and at suitable temperature, fungi spread rapidly by means of **spore**; the reproductive structure that gives rise to new plant bodies directly. Most fungi reproduce sexually as well as asexually. '**Imperfect fungi**', however, reproduce only asexually.

5.1.2 Classification of Fungi

There are approximately one lakh known species of fungi which are classified on the basis of structure of **sporangium** (spore-producing structure), methods of spore formation and characteristics of mycelium. Four large groups of fungi are the **Zygomycetes** (examples: *Rhizopus*), the **Ascomycetes** or 'sac fungi' (examples: *Penicillium*, morels and yeasts), the **Basidiomycetes** (examples: rusts, smuts and mushrooms) and the **Imperfect fungi** (example: *Alternaria*)

5.1.3 *Rhizopus*

It is a common black bread mold' which is found growing on bread, pickles, other food and also leather materials. It can be grown within a few days by keeping moistened pieces of bread under a bell jar because its spores are always found every where in the air. Such fungi are commonly called molds.

Mycelium of *Rhizopus* consists of many tubular, non-septate and **coenocytic**

hyphae. The hyphal wall contains **chitin**. The cytoplasm contains many nuclei, vacuoles and fat droplets. In *Rhizopus*, three types of hyphae are founds, which are stolons, rhizoidal hyphae and

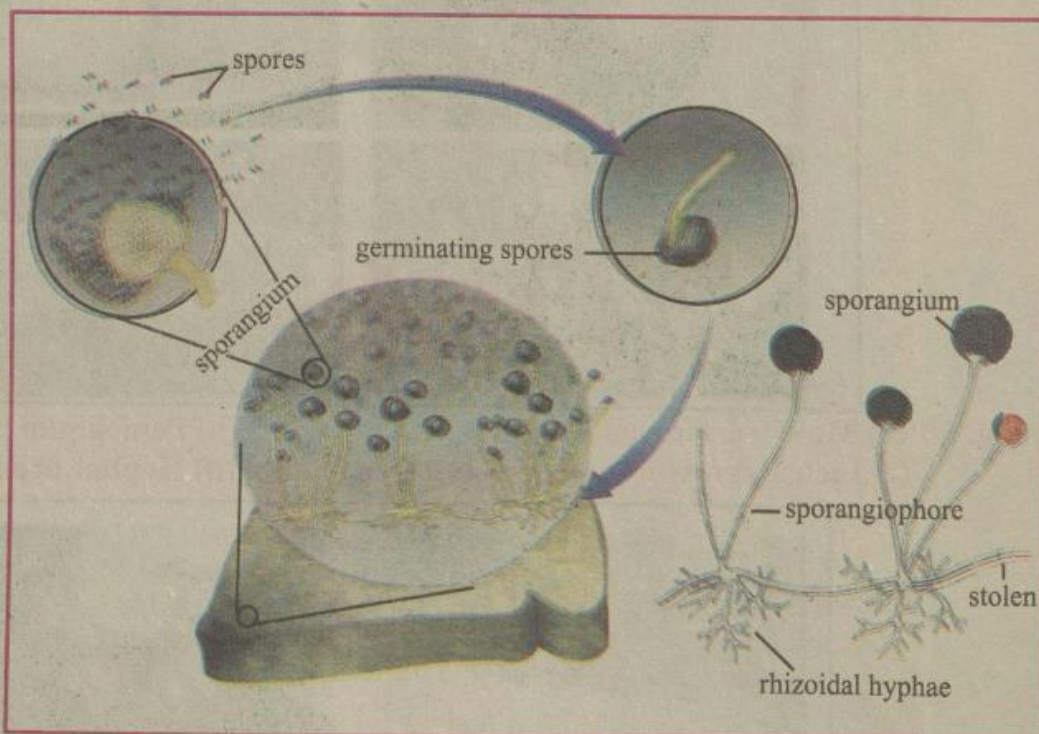


Fig 5.2 Structure of *Rhizopus*

sporangiohores. **Stolons** are the hyphae which spread along the surface of the substrate on which the fungus grows; **rhizoidal** hyphae penetrate the substrate, spread within, break down the food into simpler substances with the help of **enzymes** they secrete, and absorb the digested food material; **sporangiohores** are vertical hyphae which bear sporangia at their tips. A single, rounded sac-like black **sporangium** is formed at the tip of each sporangiophore. A very large number of small-sized and light-weight but tough and resistant spores are produced inside each sporangium. Spores are dispersed by wind. When the spores land on a suitable place (substrate), they germinate, giving rise to new fungal mycelium. In addition to this asexual reproduction, *Rhizopus* also reproduces by sexual method..

Practical work: Study of *Rhizopus*

1. Take a piece of moldy bread.
2. Observe white, thin threads and white or black dot like structures of 'black bread mold' *Rhizopus* seen on the bread. Name these structures.
3. Put a drop of clean water on a glass slide. With the help of forceps, transfer some material of *Rhizopus* to the drop of water on the slide; spread the threads with the help of needles and place a cover slip over it.
4. Study this slide (prepared by you) under the microscope, first under low power and then under high power objective lenses.
(You may also study *Rhizopus* from its prepared slide provided to you).
5. Draw a figure of the structures that you see and label its parts.

4.1.4 Mushroom

Mycelium of mushroom is saprotrophic, spreading under ground in the soil that contains decaying organic matter. At some point when spores are to be formed, many hyphae of the mycelium go on to form umbrella shaped **fruit body**, the familiar **mushroom**-which appears above ground. It can be 3, 4 inches in height.

Fruit body consists of two main parts; a lower stalk or **stipe**, and an upper umbrella-shaped cap or **pileus** which bears **annulus** around it just below the cap. In a mature (or ripe) fruit body, many radial plates or gills can be seen on the underside of the cap. Enormous number of spores are produced on these gills. Some mushrooms, for example *Agaricus*, can be used as food before their fruit bodies become overripe. Some mushrooms, for example *Amanita*, are however, deadly poisonous.

Poisonous mushroom are also called **toadstools**. *Amanita* is a highly poisonous mushroom genus. A person may die by eating a single cap of *Amanita*, hence called 'death cap' or 'destroying angel'.

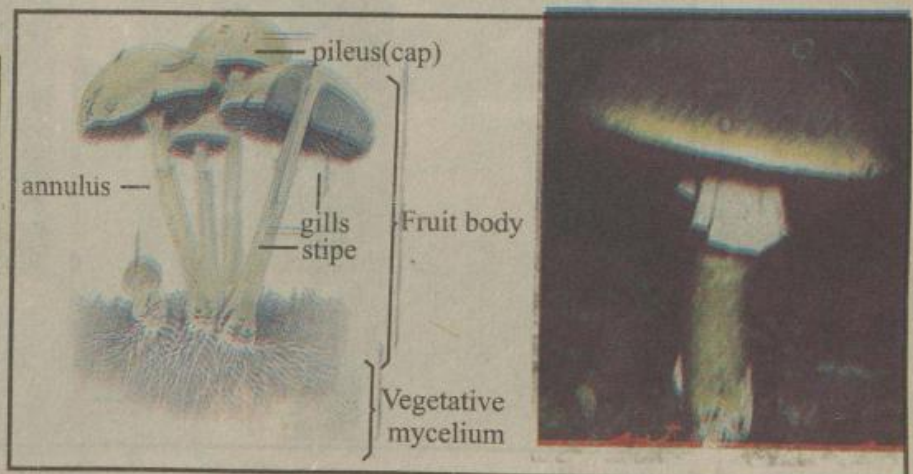


Fig 5.3 (a) Structure of mushroom (b) Poisonous toadstool (*Amanita*)

Practical work: Study of Mushroom

1. Observe preserved specimen of an umbrella-shaped mushroom. Which part of fungus is this mushroom?
2. Draw its figure and label its parts. Where are the spores of this fungus formed?

5.1.5 Importance of Fungi

Fungi are useful as well as harmful to humans.

Useful aspects of Fungi

1. Saprotrophic fungi chemically break down corpses of dead organisms and their wastes into simple components. This fungal decomposing is of great ecological importance as they clean the environment and also cause the recycling of nutrients, which can be used again and again by the organisms.
2. Mycorrhizal fungi improve the growth of crop plants.
3. Mushrooms and some other fungi are edible.
4. Some antibiotics are also obtained from certain fungi. For example penicillin, the first antibiotic discovered in 1928 by Alexander Flemming.
5. Yeasts are used in making bread and alcohol.
6. Some organic acids, such as fumaric acid and citric acid which are of diverse use, are obtained from some fungi.

Harmful aspects of Fungi

1. Fungi cause several diseases in plants and also some diseases in animals and humans. *Puccinia* causes **rust** while *Ustilago* causes **smut** in wheat and maize. *Candida*, (yeast), is the cause of thrush in man's throat. Some other fungal diseases of humans include athletes' foot (caused by *Epidermophyton*) **ringworm**, and histoplasmosis (a disease of lungs). Some fungi are also found in the ears and cause diseases.

Aflatoxins are the mycotoxins produced by *Aspergillus*. Consumption of food that is contaminated with this fungus is very harmful to the liver and may even cause cancer.

2. Saprotrophic fungi cause a lot of damage to food, wood and leather materials. *Rhizopus* (black bread mold), *Penicillium* (blue, green mold of orange) and the 'bracket fungus' growing on tree trunks are all examples of such saprotrophs.

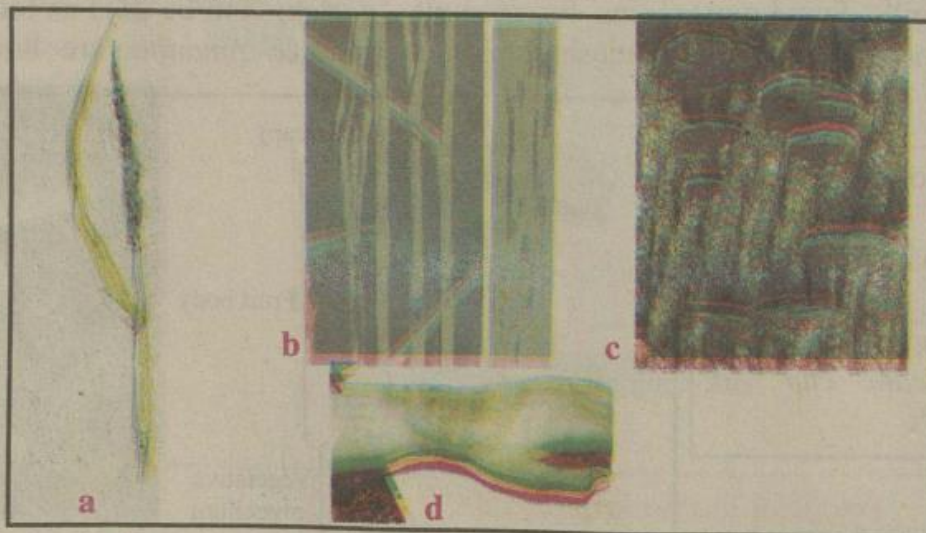


Fig. 5.4 (a) *Ustilago* (smut) on ear of wheat (b) *Puccinia* (rust) on wheat stem (c) Bracket fungus on tree trunk (d) Ringworm on human wrist.

Algae are simple eukaryotes which, like plants, are chlorophyllous, photosynthetic autotrophs and have cellulose in their cell wall. However, unlike plants but like fungi, their reproductive organs are unicellular and body is simple, thallus. So they are placed in another kingdom, the Protista.

Algae are mostly aquatic (found in water) A large number of algae are marine (that is, found in vast salt water of oceans), while other are fresh water (found in lakes, ponds, puddles stream and rivers).

5.2.1 Types of Thallus in Algae

Algae exhibit wide range of thallus from unicellular to complex one.

- **Unicellular thallus**

Some algae are single celled but the cell possess all the attributes of life. *Chlamydomonas* is an example of a motile, while *Chlorella* a non-motile, unicellular alga.

- **Colonial thallus**

In a simple colony, many similar cells are embedded in a common sticky mucilaginous mass. *Volvox* is an example of motile colonial form, while colony of *Pediastrum* is non-motile.

- **Filamentous thallus**

In this type of thallus, many cells are joined from end to end to form a long **filament**. Filaments of *spirogyra* are unbranched while those of *Cladophora* are branched. Thallus of some marine algae is very large sized with complex external and internal structure. Thalli of *Sargassum* and **sea plam** are so complex that they look like having leaves and stem. Algae reproduce both sexually and asexually.

Some marine algae, called the **kelps**, can grow as long as 60 meters or more in a season. Some of the kelps are used as food.

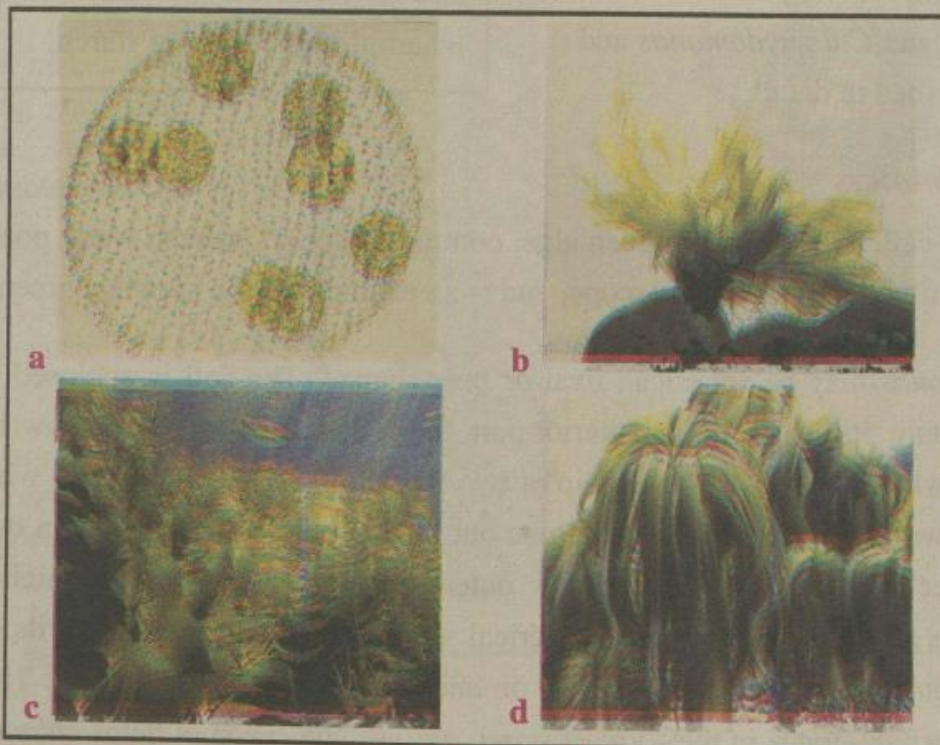


Fig. 5.5 (a) *Volvox* colony (b) *Ulva* or sea lettuce (c) A kelp (d) Sea palm

5.2.2 Classification of Algae

There are approximately 23 thousand known species of algae which have been classified on the basis of their photosynthetic pigments, reserve food material and method of reproduction. Large groups of algae are **green algae**, **brown algae**, **red algae**, **golden brown algae** and **diatoms**.

Diatoms are the most important primary photosynthetic producers in the aquatic food chains (or in water or in the ocean), second being the dinoflagellates.

Maximum photosynthesis in the water or the oceans is carried out by diatoms, and next by dinoflagellates. '**Red tide**' is caused due to enormous numbers of dinoflagellates toxins produced in warm waters during summers. Red tide can kill fish; even humans may be badly affected by consuming (eating) such fish. The poisons produced by red-tide species may accumulate in the bodies of some aquatic animals such as mussels etc. Flesh of such animals may become toxic to humans and its consumption may cause a serious and even fatal illness, called "mussel poisoning".

The green algae include species with all types of thalli. Most of the biologists are of the view that some green algae could be the ancestors of plants.

Two green algae, *Chlamydomonas* and *Spirogyra*, are described in detail.

Green algae are considered to be ancestors of plants because both the groups contain same photosynthetic pigments (chlorophylls "a" and "b", and carotenoids) and reserve food material in the form of starch.

5.2.3 *Chlamydomonas*

It is a single-celled, fresh water green alga, commonly found in fresh water ponds and drains. It can be clearly seen only under a microscope, and is an example of the simplest green algae.

Chlamydomonas may be spherical, oval or pear-shaped. The cell is enclosed by a cell wall which help to maintain its shape. In the anterior part, the **cell wall** forms an outgrowth called **apical papilla**. The cell swims in water with the help of two **flagella** (singular flagellum) which arise from the cytoplasm below the **apical papilla** and come out through the cell wall. A thin **cell membrane** lies beneath the cell wall; it represents the outer surface of cytoplasm, which functions in photosynthesis. The chloroplast contains a spherical structure called pyrenoid in its posterior part, and a single red-orange, light-sensitive *eye-spot* on one side in its anterior regions. The **pyrenoid** is supposed to store carbohydrates in the form of starch grains. The eye spot helps *chlamydomonas* to determine its position and direction according to changes in the intensity of light.

Practical work: Study of *chlamydomonas*

1. Study the prepared slide of *Chlamydomonas* provided to you under the microscope, first under low power and then under high power objectives.
It is a unicellular green alga.
2. Draw its diagram and label different parts.
3. What is the shape of its chloroplast?

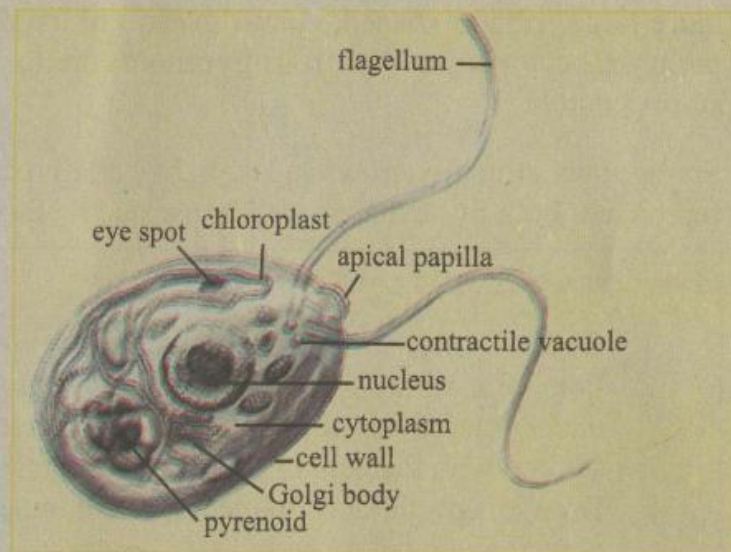


Fig. 5.6 Structure of *chlamydomonas*

It has two contractile vacuoles near the base of flagella. These vacuoles periodically expel excess water and wastes from the cell. A nucleus at present in the middle of chloroplast in the cytoplasm. *Chlamydomonas* reproduces both sexually and asexually. Although body of *chlamydomonas* consists of a single cell, yet it performs all the basic functions of life.

5.2.4 Spirogyra

Spirogyra is a genus of multicellular filamentous green algae occurring in great abundance in fresh water ponds, lakes and streams. Its filamentous thallus consists of many cylindrical cells which are joined from end to end to form long, unbranched **filaments**. Usually the filaments are found occurring together in a very large number. The filaments are surrounded by a layer of **mucilage** that makes them sticky. During day time, the oxygen produced during photosynthesis accumulates in the mucilage and the filaments start floating on the surface of water.

Each cell of spirogyra is usually twice as long as broad. The cell is surrounded by cellulosic cell wall. A peripheral layer of cytoplasm is present just inside the cell wall and around a large, central **cell sap-filled vacuole**. The nucleus is suspended near the vacuole by **cytoplasmic strands**; these strands connect to the peripheral cytoplasm. Each cell contains one or

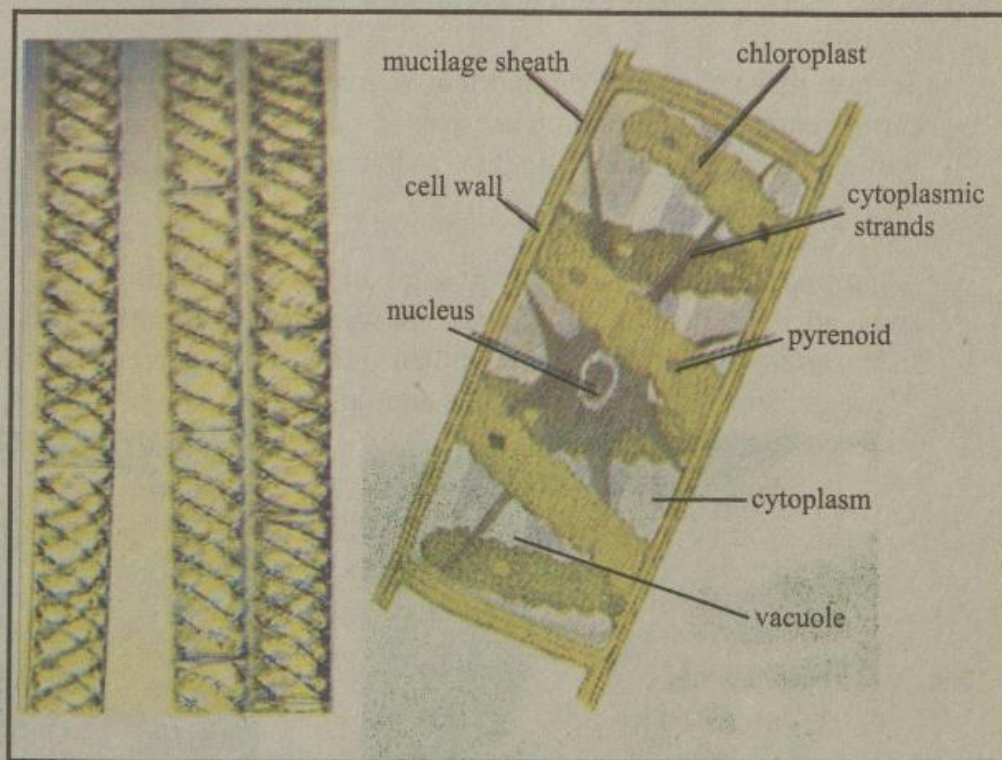


Fig. 5.7 Spirogyra: Filament and a cell

more large, ribbon shaped, spiral, **green chloroplasts** that run along the length of the cell in the peripheral cytoplasm. Numerous **pyrenoids** are located in a row in the chloroplast and are meant for storing starch.

Spirogyra continually grows in length by cell division; each cell can divide into two. The *Spirogyra* reproduces both by sexual as well as asexual methods.

Practical work: Study of *Spirogyra*

1. Observe long, thread like, green filaments of *Spirogyra* provided to you in a jar of water.
2. Prepare a slide of a few filaments of *Spirogyra* and study them under a microscope, first under low power objective, and then under high power objective. (*Spirogyra* can also be studied with the help of prepared slide provided to you).
3. Draw diagrams of a filament as seen under the low power and of a single cell under high power, and label its parts.
4. Describe the shape of a filament, a cell and chloroplast.

5.2.5 Economic importance of Algae

Algae are economically useful; however they are also harmful in some respects.

Uses of Algae

1. They are source of food for all aquatic animals (fresh-water as well as marine)
2. Algae carry out 90% of all the photosynthesis taking place in aquatic environment. The oxygen gas produced during photosynthesis by these algae keeps the environment favourable for the aerobic organisms.
3. Some marine algae are used as food for humans and animals; these are also used as manure in the fields.
4. Several marine algae are important source of (many) commercial materials, for example algin, carrageenan and agar which are used in cosmetics, drugs and in culture media for bacteria.
5. Some antiseptics, such as tincture iodine are also obtained from some marine algae.

Harmful aspects of Algae

1. Algae spoil the taste of drinking water and give it a bad odour.
2. some algae produce toxic materials in water which produce diseases in cattle, other animals, fishes and may also kill them. Humans may also be adversely affected, as by the toxic red tide.
3. Algae growing in fountains, pools and falls of recreational sites spoil their beauty.



Fig. 5.8 (a) 'Red tide'



(b) An edible red alga (*Palmaria palmate*)

KEY POINTS

1. According to two-kingdom system of classification, 'algae' and 'fungi' are considered plants due to the presence of cell walls; they are grouped together in sub-kingdom 'Thallophyta' of 'plant' kingdom.
2. Body of fungi and algae is simple, which is not differentiated into root, stem and leaves; such a body is called 'thallus'.
3. Reproductive organs of fungi and algae are unicellular and not surrounded by sterile protective cells.
4. According to five- kingdom system of classification, fungi have been separated from plants because of characteristic structure of their cell wall and absence of chlorophyll, and placed in a separate kingdom of their own 'Fungi'.
5. Algae, along with Protozoa and some other simple aquatic eukaryotes, have been placed in another kingdom known as 'Protista'.
6. Fungal body or 'thallus' is called mycelium which consists of tubular thread like hyphae.
7. Fungal cell wall contains chitin instead of cellulose.
8. All fungi are heterotrophs with absorptive nutrition; some are parasites, others are saprotrophs and a few are mutualists.
9. Fungi are classified on the basis of structure of sporangium, method of spore formation and mycelial characters. Zygomycetes, Ascomycetes, Basidiomycetes and 'Imperfect Fungi' are four main groups of fungi.
10. *Rhizopus*, the 'black bread mold', is found on food and leather materials; its mycelium consists of non-septate and coenocytic hyphae; its mature sporangium produces black spores which are responsible for its rapid spread.
11. Vegetative mycelium of mushroom is underground while above ground visible part is its 'fruiting body'. The fungus spreads with the help of spores produced in the fruiting body. Some mushrooms are edible, for example *Agaricus*, while others may be poisonous, for example *Amanita*.
12. Algae are simple, aquatic, autotrophic eukaryotes with 'thallus' body, which may be unicellular, colonial, or filamentous or some other form. Many algae are marine while others are found in fresh waters.
13. Algae are classified on the basis of their photosynthetic pigments, reserve food material and method of reproduction. Main groups of algae are green algae, brown algae, red algae, golden-brown algae and diatoms.
14. *Chlamydomonas* is an example of fresh-water, motile, unicellular green algae. *Spirogyra* is a fresh water, non-motile, filamentous green alga.
15. Green algae and plants possess the same photosynthetic pigments and reserve food material; hence most of the biologists consider some ancient green algae as the possible ancestors of plants.
16. Role of fungi as 'decomposer' and of algae as 'producers' make them indispensable in natural environment. They can also be used to overcome human food problem.
17. Fungi and algae are of great ecological as well as economic importance; they are useful as well as harmful.

QUESTIONS

1. Fill in the blanks

- (i) Fungi which obtained their food from dead animals and plants or their wastes are called _____.
 - (ii) The hyphae of *Rhizopus* which absorb food from bread are known as _____.
 - (iii) In _____, the chloroplast is spiral ribbon-shaped.
 - (iv) In mushrooms, spores are produced on plate like structure called _____.
- a. An example of motile, colonial green alga is _____.
 - b. The prominent part of mushroom is its _____.

2. Write whether the statement is 'true' or 'false'. Correct the statement if it is false.

- c. In majority of fungi; cell wall is made up of cellulose.
- d. Some mushroom are edible whereas morels is an examples of poisonous mushroom.
- e. *Chlamydomonas* is a multicellular motile green alga.
- f. Photosynthetic pigments and stored food material in green algae are same as are found in all plants.
- g. Coenocytic hyphae are those septate hyphae which contain many nuclei.

3. Each question is followed by four options. Encircle the correct answer.

- (i) What characteristics are found in both algae and fungi?
- (a) Presence of cell wall, thallus and multicellular reproductive organs.

- (b) Presence of thallus, chlorophyll and cell wall.
- (c) Presence of cell wall, thallus and unicellular reproductive organs.
- (d) Presence of thallus, chlorophyll and unicellular reproductive organs.
- (ii) Which are not edible?
 - (a) Toadstools (b) *Agaricus* mushrooms
 - (c) Kelps (d) Morels
- (iii) Pick the odd alga with respect to its body structure.
 - (a) *Spirogyra* (b) *Chlamydomonas*
 - (c) *Sargassum* (d) *Volvox*
- (iv) Those organisms which obtain their food from other living plants and animals are called:
 - (a) Saprotrophs (b) Parasites
 - (c) Autotrophs (d) Mutualists
- (v) Presence of unicellular reproductive organs, thallus and chlorophyll are characteristics of
 - (a) Fungi (b) Algae
 - (c) Bryophytes (d) Vascular plants.
- (vi) Which characteristics is found in all fungi?
 - (a) Heterotrophic (b) Parastic
 - (c) Unicellular thalles
 - (d) Coenocytic hyphae
- (vii) Mycelium is not found in
 - (a) *Agaricus* (b) *Rhizopus*
 - (c) *Yeasts* (d) *Penicillium*

4. Identify the following diagram and label its parts.

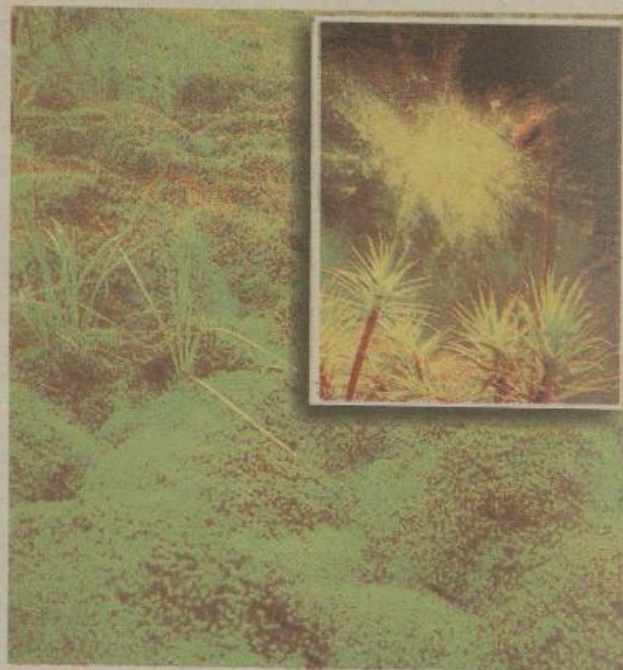


5. What is meant by thallus and thallophytes?
6. What are fungi? Describe their important characteristics.
7. Why have fungi been separated from plants and placed in a separate kingdom of their own?
8. Describe economic importance of fungi.
9. What are algae? Describe similarities and differences between algae and fungi.
10. Explain with examples different kinds of thallus found in algae.
11. Describe the structure of *Chlamydomonas*.
12. With the help of diagram, describe the structure of a filamentous green alga.
13. Write a note on economic importance of algae.
14. How fungi and algae are helpful in overcoming the problem of shortage of food?

BRYOPHYTES

In this chapter you will learn:

- Important characteristics of plants and differences between their two groups (bryophytes and tracheophytes).
- Characteristics of bryophytes and names of their main groups.
- Structure and life-cycle of *Funaria* (a moss).
- Comparison of bryophytes, tracheophytes and algae.



Bryophytes are one of the two main groups of kingdom 'Plantae' the second being the 'tracheophytes'.

Plants are multicellular, photosynthetic eukaryotes; their reproductive organs are multicellular; their zygote develops into a small, protected **embryo** that develops into a complete new plant, hence bryophytes have also been called **embryophytes**, and they have cellulose-containing cell wall.

6.1 Characteristics of Bryophytes

Bryophytes are the plants without vascular tissue (**xylem, phloem**), whereas tracheophytes have vascular tissue. So **tracheophytes** are **vascular plants**, while **bryophytes** are **non-vascular plants**.

Bryophytes are the simplest land plants. **Liverworts, hornworts, and mosses** are three groups of bryophytes. *Marchantia* is an example of liverworts; its plant body is a thick branched, green thallus. *Anthoceros* is a hornwort, and *Funaria* a moss. All bryophytes are generally found living in moist habitats such as damp soil and rocks, moist brick walls, and along the banks of streams. Although the bryophytes have mostly dispensed with water, still they need water for their sexual reproduction because their male gametes are flagellated and motile. For this reason, the bryophytes are also called **amphibious** plants.

Bryophytes are small plants. Most of them are only 1-2 cms in size. They lack true roots, stems, or leaves. However, most of them possess stem-like structures and leaf-like structures. Instead of roots, they possess hair like **rhizoids** for the absorption of water and salts from the soil, and for anchoring the plant to the soil. However, none of these parts contains definite vascular tissue. Plant surface in most bryophytes is covered over with a thin waxy layer which prevents the loss of water by evaporation on land. Such features enable bryophytes to survive on land. They can reproduce sexually as well as asexually.

Bryophytes are not large plants. They are typically quite small. Why? They lack vascular tissue. How are, then, water, salts and food materials etc transported within their body?

The bryophyte plant produces gametes and is called **gametophyte**. It is **haploid-n**. Male and female gametes fuse to form a **diploid (2n)** zygote, which forms by mitosis another generation. This generation is diploid (2n) and produces **spores**, not gametes, and is called the **sporophyte** generation. The **sporophyte** generation is attached with, and partly or completely dependent on the gametophyte for its food and water. So dominant plant is **gametophyte generation**.

Meiosis occurs within the sporophyte, producing haploid (n) spores, which are dispersed by wind. If spore lands at a suitable place and temperature is favourable, it germinates and forms eventually a new haploid (n) gametophyte plant.

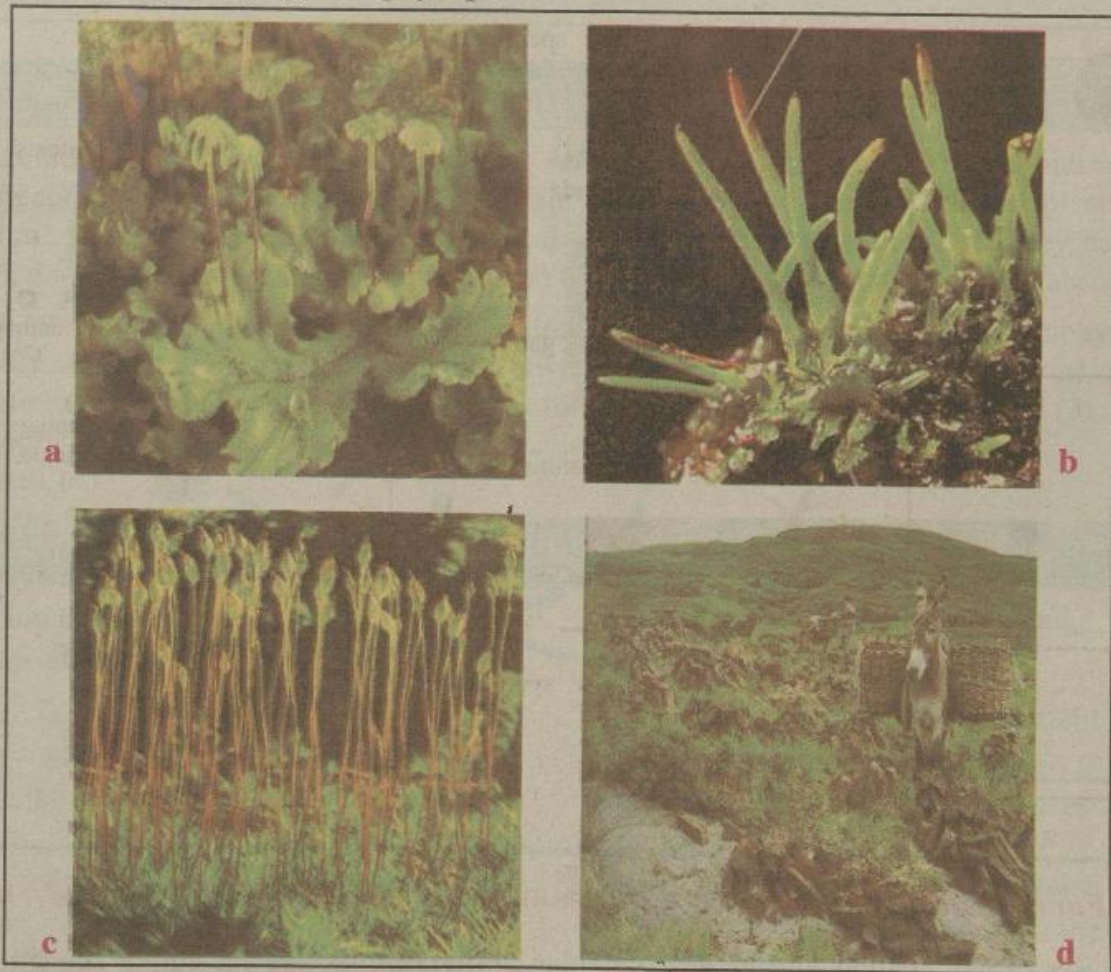


Fig. 6.1 (a) a liverwort (*Marchantia*) (b) Hornwort (*Anthoceros*) (c) A moss (d) Peat moss (*Sphagnum*)

So in the life cycle of bryophytes, two types of multicellular generations-‘sporophyte’ and ‘gametophyte’ alternate with each other; the gametophyte generation gives rise to sporophyte generation and the sporophyte gives rise to gametophyte. This phenomenon is called ‘**alternation of generations**’. As you will study in the later chapters, all higher land plants.-the vascular plants-also exhibit alternation of generations. However dominant generation –the leafy green plant-of vascular plants is ‘sporophyte’, in bryophytes the dominant of generation is gametophyte.

Atleast 30% of the earth’s surface is covered with peat-mosses (*Sphagnum*), which are probably the most abundant land plants. In some countries, peat is also used for fuel.

6.2 Funaria

It is a common moss found growing at damp places. Green leafy, moss plant of *Funaria*, as of all bryophytes, is haploid gametophyte.

The plant is about half an inch to an inch tall. It consists of 3 parts: a vertical **stem like structure**; **leaf like** photosynthetic structures arranged on the stem, composed of a single layer of cells, and without stalk; and numerous multicellular **rhizoids**, arising from the lower side of the stem and absorbing water and salts, and anchoring the plant to the soil.

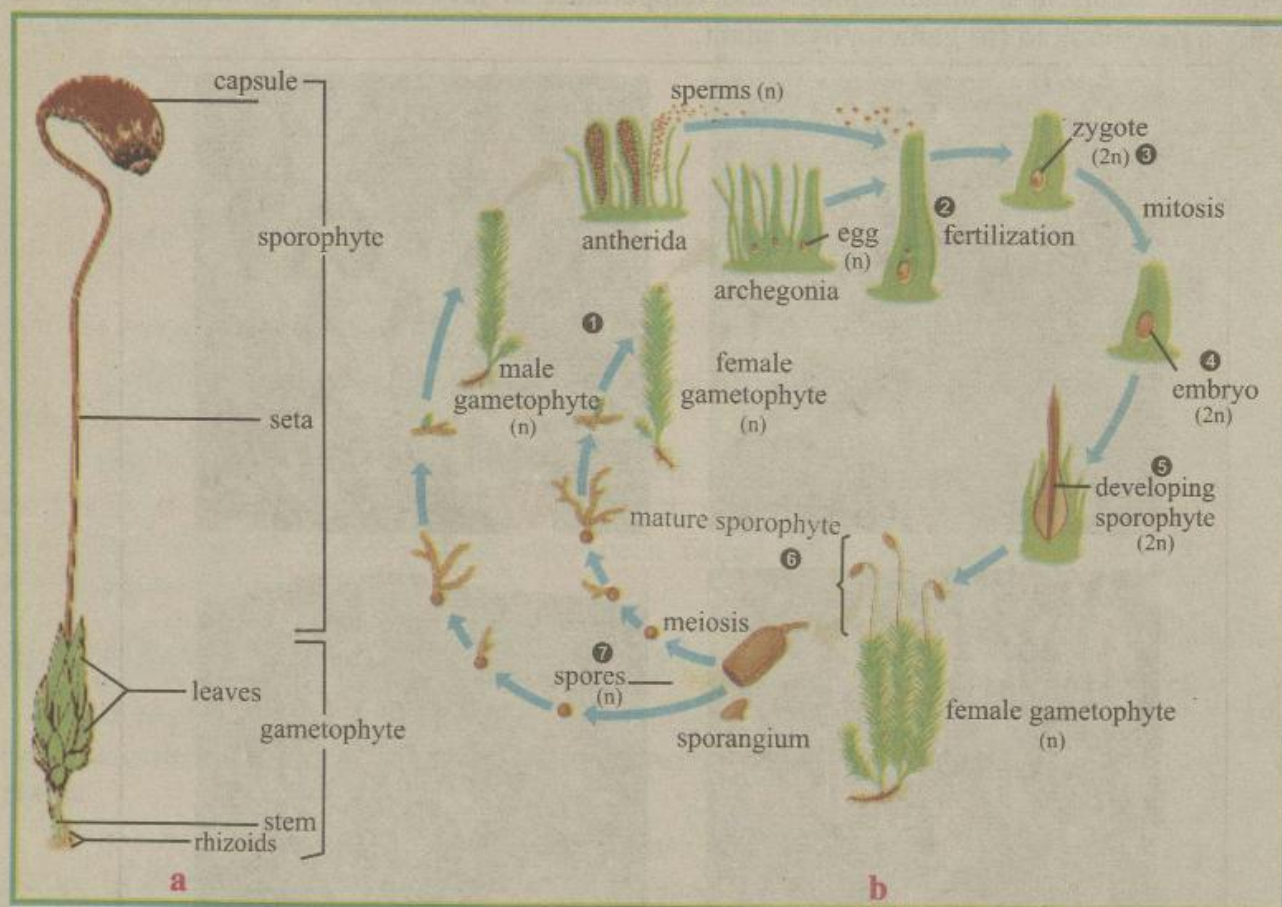


Fig. 6.2 *Funaria* moss, (a) gametophyte with attached sporophyte (b) Life cycle of a moss

Male sex organs, called **antheridia** (singular **antheridium**), are located at the tip of male branch, and the female sex organs, called **archegonia** (singular **archegonium**) are located at the tip of female branch. **Fertilization** occurs in the presence of water within the archegonium located at

the tip of female branch. The embryo and then the sporophyte developing from the zygote, therefore, remains attached to the tip of female branch. The sporophyte gets water, salts, and also part of its food, from the parent gametophyte plant.

The sporophyte consists of three parts: (1) a **foot**, (2) a long stalklike **seta**; and (3) **capsule**. The foot is anchored to the female branch and absorbs nutrients from the gametophyte. The seta elevates the capsule in the air. Within the capsule, meiosis occurs and haploid spores are produced. The spores are dispersed by wind and may develop eventually into new haploid gametophyte plant, and the life cycle continues.

So, as in other bryophytes, *Funaria* also has well defined alternation of generations; haploid gametophyte generation is dominant, whereas diploid sporophyte is attached to and more or less dependent on the gametophyte.

Practical work: Study of *Funaria*

1. Study *Funaria* (moss) plant provided to you. What is its approximate size?
2. Draw a diagram of *Funaria* plant and label its parts.
Name the structures that anchor the plant and function in the absorption of water from the soil.
What apparent difference, other than that in size, do you observe in its leaves and those of any flowering plant?
3. Observe the sporophyte that is attached to the gametophyte, draw its diagram, and label different parts.

KEY POINTS

1. According to five-kingdom system of classification, two major groups of 'Plant' kingdom are (1) bryophytes (non-vascular plants), and (2) tracheophytes (vascular plants)
2. All plants have alternation of generation. However, in the bryophytes, the gametophyte generations is dominant; whereas in the tracheophytes the sporophyte generation is dominant.
3. Bryophytes inhabit moist places; they are amphibious plants; they are simplest land plants. Bryophytes are small plants. They have rhizoids to anchor the plant and to absorb water.
4. Three main groups of bryophytes are (1) liverworts (example: *Marchantia*), (2) mosses (example: *Funaria*), and (3) hornworts (example: *Anthoceros*)

QUESTIONS

1. Fill in the blanks

- (i) Bryophytes include liverworts, _____, and hornworts.
- (ii) Bryophytes have structures called _____, for the absorption of water and minerals.
- (iii) In bryophytes, _____ generation is the familiar, dominant plant.
- (iv) The spore-producing part of *Funaria* sporophyte is called _____.

- (v) *Marchantia* is liverwort, and _____ is an example of a moss.

2. Write whether the statement is 'true' or 'false' and correct the statement if it is false.

- (i) *Funaria* plant which produces sex organs is called sporophyte.
- (ii) Sporophyte of *Funaria* obtains nutrients from the gametophyte with the help of rhizoids.
- (iii) Gametophyte of all bryophytes is haploid,

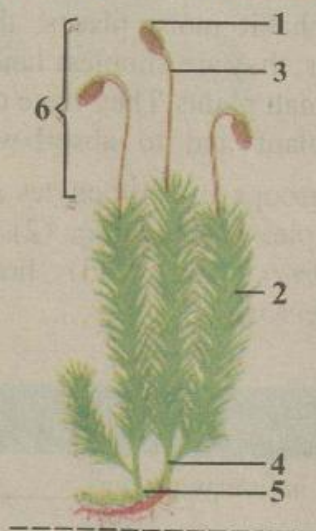
while the sporophyte is diploid.

- (iv) Gametophyte of a moss consists of stem like structure, leaf like structures, and roots.
- (v) Bryophytes are the simplest land plants.
- (vi) In the life cycle of a plant, the gametophyte generation develops from the zygote and the sporophyte generation develops from the spore.

3. Each question is followed by four choices. Encircle the correct answer.

- (i) Bryophytes include
 - (a) liverworts, mosses (b) ferns, gymnosperms
 - (c) gymnosperms, angiosperms (d) mosses, fungi
- (ii) Mosses are closest to
 - (a) ferns (b) gymnosperms
 - (c) liverworts (d) angiosperms
- (iii) Which of the following statements is not true about mosses?
 - (a) the moss plant is gametophyte (b) absorb water by roots
 - (c) lack vascular tissue (d) have stem like structures and leaf like structures.

4. Identify the following diagram and answer the question related to it.



- (i) The part labelled 5 is
 - (a) foot (b) capsule (c) stalk (d) rhizoids
- (ii) Cells of the part labelled 2 are
 - (a) haploid (b) diploid (c) without chlorophyll
 - (d) part of sporophyte generation
- (iii) Meiosis occurs in part/parts labeled
 - (a) 1 (b) 2 (c) 5 (d) both 1 and 2
- (iv) Which of the following structures is not found in this plant?
 - (a) stem (b) leaf (c) root (d) none of answers a, b, c is correct.

5. State distinguishing characteristics of plants. Why are the plants also called embryophytes?

6. Name the two largest groups of plants and also write important differences between the two groups.

7. Describe characteristics of bryophytes. Why are they called 'amphibia' of 'plants'?

8. What is meant by alternation of generations?

9. Explain structure of *Funaria* gametophyte. Also write down the names of different parts of *Funaria* sporophyte.

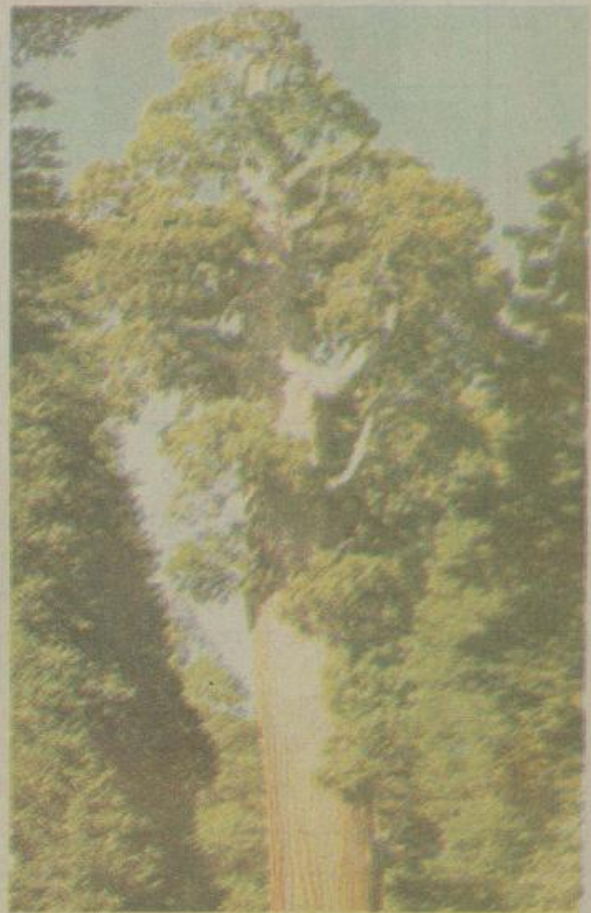
10. How do bryophytes differ from other plants and green algae?

11. "Bryophytes are the simplest land plants". Discuss.

TRACHEOPHYTES OR VASCULAR PLANTS

In this chapter you will learn:

- Characteristics of tracheophytes and their major groups.
- Characteristics of pteridophytes.
- Structure and life cycle of ferns.
- Characteristics of gymnosperms and their comparison with those of pteridophytes and angiosperms.
- Structure of conifers (with reference to *Pinus* and *Thuja*).
- Characteristics of angiosperms.
- Comparison of monocots and dicots with examples of each.
- Structure of an angiosperm plant.
- Importance of angiosperms.



You studied in the previous chapter that bryophytes do not possess conducting or vascular tissues for the transport of water and food. Contrary to this, three major groups of plants i.e. pteridophytes, gymnosperms and angiosperms have vascular tissues and are thus called “tracheophytes” or vascular plants (Fig.7.1).

Recall that vascular tissues consist of groups of specialized cells that conduct water from roots and synthesized food from the leaves to other parts of the plant. Vascular tissues are in the form of bundles of conducting cells. One type of vascular tissues that carry water absorbed by roots to other parts is called xylem tissue. The other type that conducts prepared food from leaves to all parts of the plant is called phloem (chapter 2).

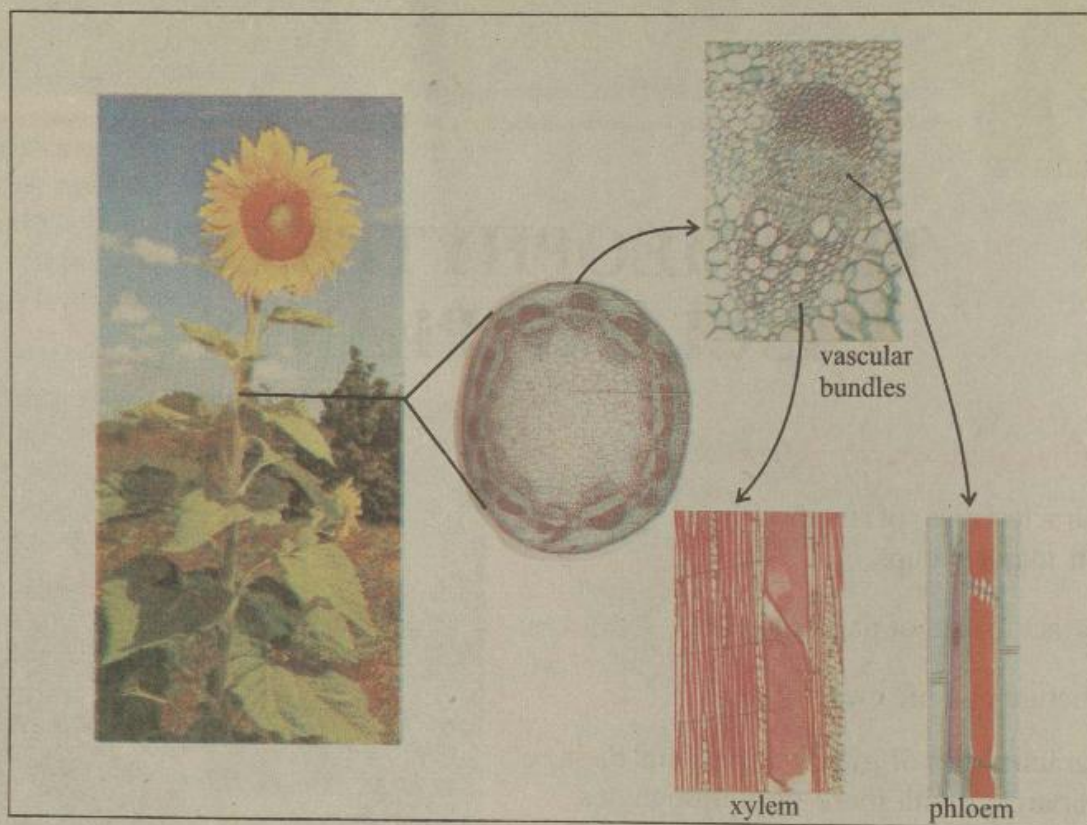
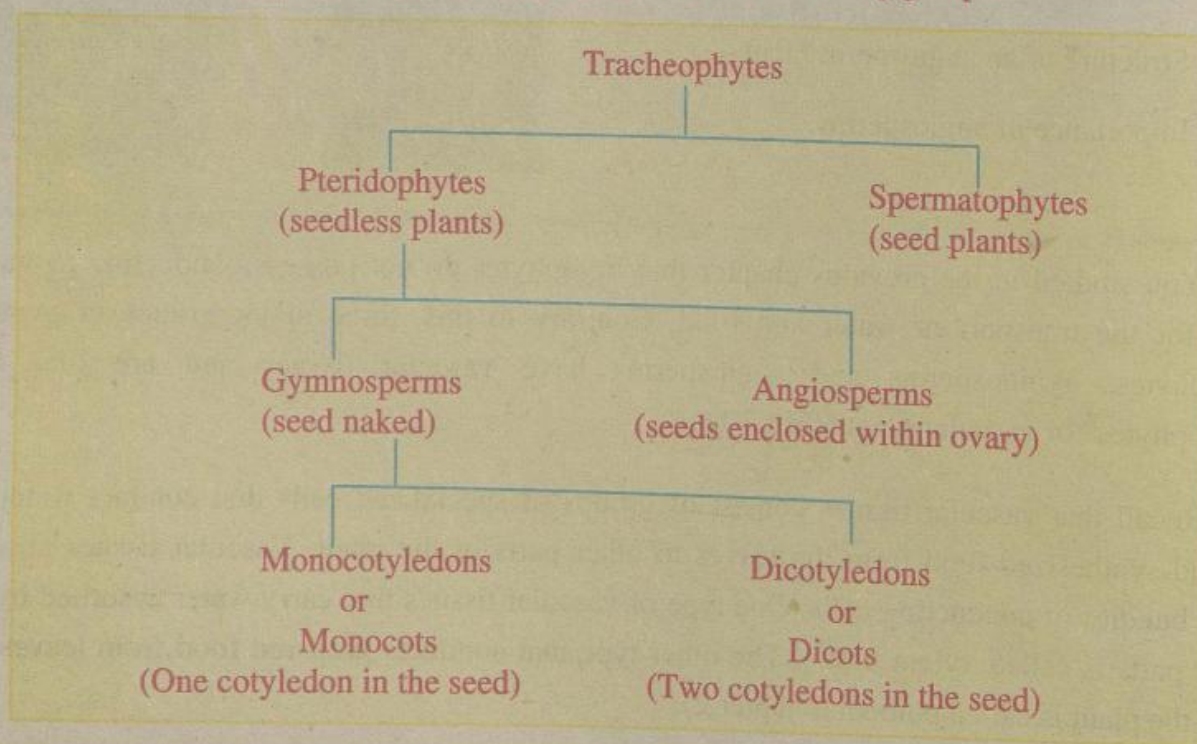


Fig. 7.1 Vascular tissues

Like all other plants, tracheophytes show alternation of generation. This means that there are two types of generations in their life cycle, sporophyte and gametophyte alternating with each other. However, in contrast to bryophytes, the sporophyte in tracheophytes is the dominant generation whereas the gametophyte is reduced, inconspicuous and dependent upon the sporophyte.

Tracheophytes can be divided into the following groups.



7.1 Pteridophytes

Unlike bryophytes the plant body in pteridophytes is differentiated into root, stem and leaves. They are similar to gymnosperms and angiosperms in possessing vascular tissues. However, in contrast to other vascular plants pteridophytes do not bear flowers, fruits and seeds.

Although the dominant phase of life in pteridophytes is also the sporophyte but unlike gymnosperms and angiosperms both sporophyte and gametophyte generations are independent and free living. However, the gametophyte is much reduced and smaller in size.

Ferns are the most common and important group of pteridophytes. Ferns prefer cool, humid and shady habitats. They are often seen growing on damp walls of wells and bridges, on banks of waterfalls and streams, and under the shade of trees. *Dryopteris*, *Pteris* and *Adiantum* are some familiar ferns (Fig.7.2).



Fig. 7.2 Different types of ferns

Ferns in general are small plants. Usually their size ranges from a few inches to a few feet. However, some "Tree Ferns" growing in the tropics may reach up to 18 metres (60 ft) in height.

Pteris is a common example of ferns. It can be found growing in damp soil on the sides of watercourses and channels (especially in northern and central Punjab). It is also grown as an ornamental plant and is available at plant nurseries.



Tree ferns

Fern plant, which is a sporophyte, consists of root, stem and leaves. Its stem is generally underground and is called a "rhizome". Rhizome of *Pteris* is

elongated and branched and grows horizontally in the soil. Adventitious roots are given off from the lower side of the rhizome and absorb water and salts from the soil.

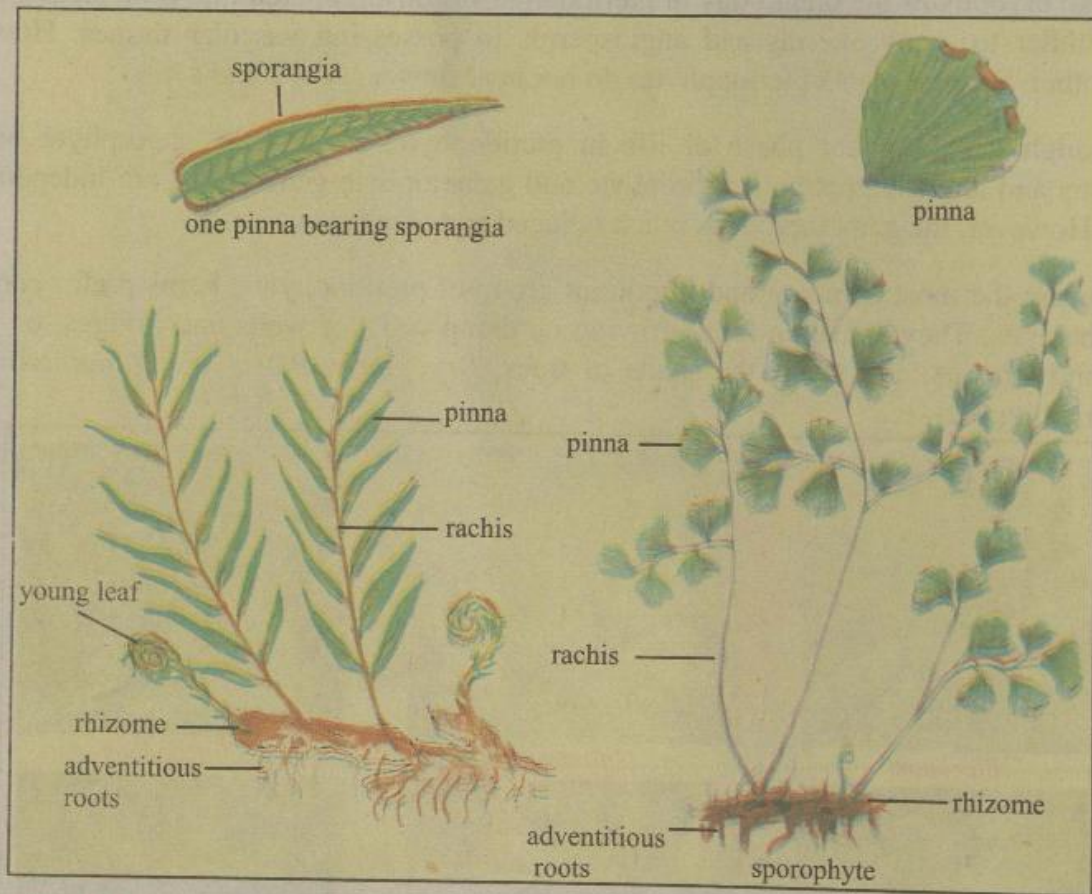


Fig. 7.3 Structure of fern (a) Pteris

(b) Adiantum

Leaves are produced from the underground stem and grow above ground. Fern leaves are usually large (one to three feet or sometimes even longer) and are called **fronds**. Lamina of the leaf is divided into a number of leaflets or pinnae (sing. pinna). Such leaves are called compound leaves. In *Pteris*, pinnae are arranged in two rows on the stalk or petiole of the leaf. The part of the petiole bearing pinnae is called **rachis**.

Young leaves are rolled from the tips and open up with age. This condition, which is called **circination**, is an important character of ferns by which they can be recognized easily (Fig.7.3).

Sporophyte is diploid, that is, it has two sets of chromosomes in its cells. It reproduces asexually by producing spores. *Pteris* leaves bear spore-producing structures called sporangia along the margins of the pinnae. The spore germinates to produce gametophyte, which is haploid. It reproduces sexually by forming gametes. The fern gametophyte is quite different in form from its sporophyte. It is very small (about the size of nail of your finger), green in colour and heart shaped. It grows flat on the soil surface. It is also called **prothallus** (Fig.7.4). Zygote resulting from the fusion of gametes gives rise to a new sporophyte.

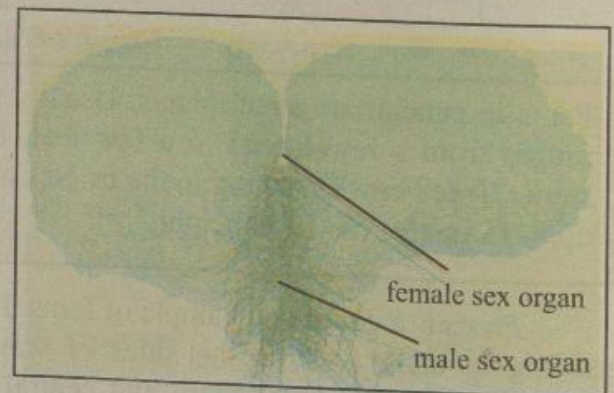


Fig. 7.4 Fern prothallus

Practical work: Study of sporangia and prothallus in fern

1. Observe pinnae of a mature *Pteris* or *Adiantum* leave on under side.

What do you see along the margins of the pinnae?

How do the margins of the pinnae look like?

On the lower side of each pinna, we can see some brown coloured structures along the margins. These are asexual reproductive structures called sporangia. In *Adiantum*, sporangia are borne along the broad margins of each pinna in the form of groups. The margins of the pinna are curled over the sporangia forming a protective cover called false inducium.

2. Remove a few sporangia from the pinna with the help of a needle. Put them in a drop of water on a clean glass slide and observe under the dissecting microscope.

Are sporangia present singly or in groups?

How does a single sporangium look like?

Which of its parts you can identify?

Draw a diagram of the sporangium, try to identify its parts as shown in the figure and label your diagram.

Can you tell what is present inside the sporangia?

3. Observe a prepared slide of fern prothallus under the dissecting microscope or study the model of the prothallus. Identify its parts according to the given figure. Draw a diagram and label it.



Sporophyte



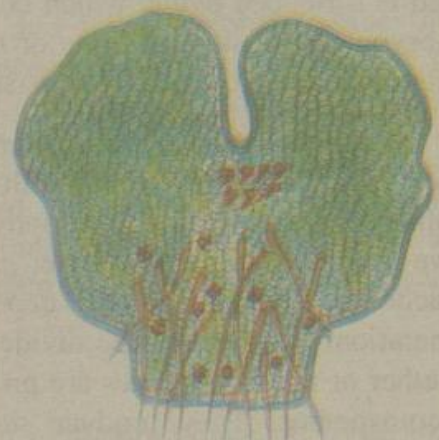
A sporangium



A pinna



Sporangia



Prothallus

Figure. Life cycle of *Adiantum*

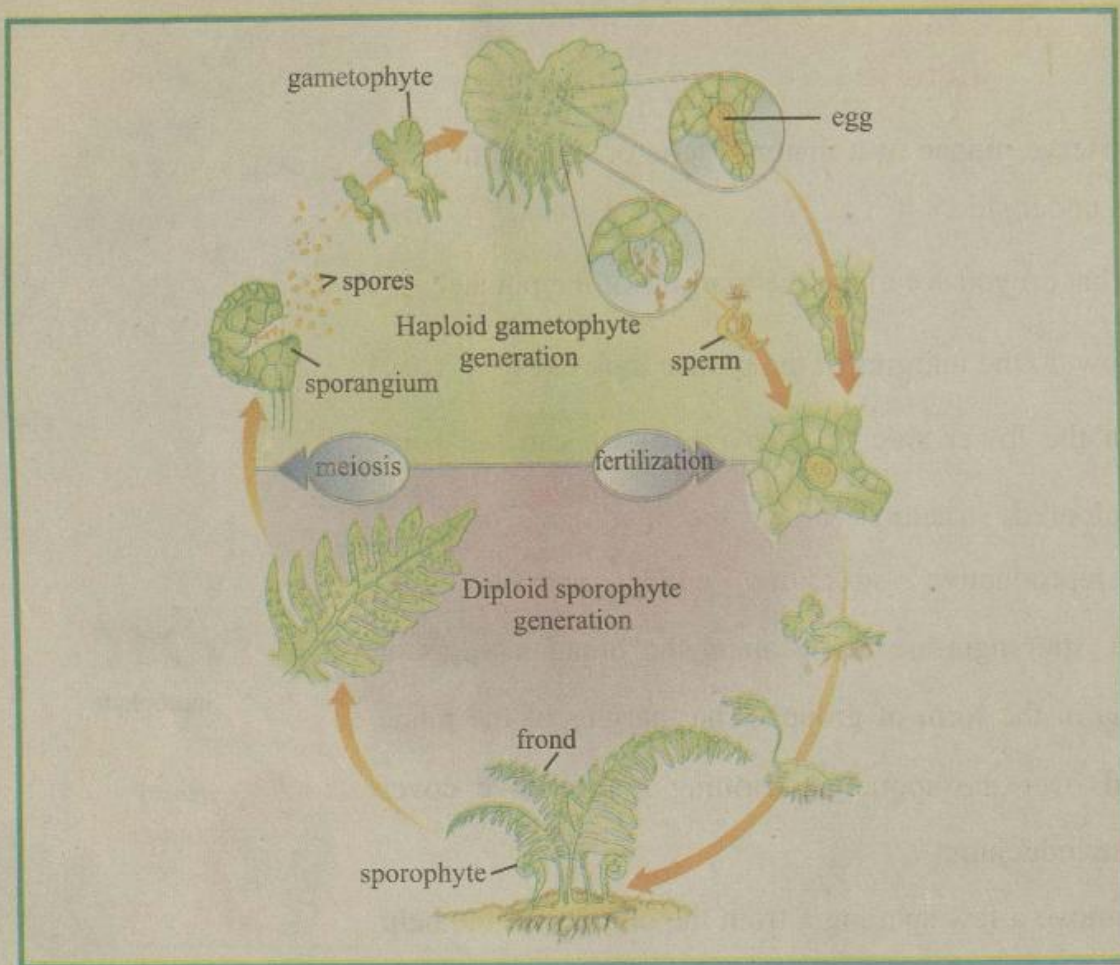


Fig. 7.5 Life cycle of a fern

Sporophyte produces gametophyte and gametophyte gives rise to sporophyte and thus, two generations appear one after the other in the life cycle of the plant. This process is called alternation of generations (Fig. 7.5). You would have noticed that, in contrast to mosses, the dominant generation in ferns is the sporophyte whereas its gametophyte is quite reduced and inconspicuous.

7.2 Seed Plants or Spermatophytes

Spermatophytes are seed producing vascular plants. Seed is a ripened ovule, which consists of a young plant with embryonic root, stem and one or more leaves, has stored food material and is protected by a resistant seed coat.

Spermatophytes like pteridophytes possess tissues. They also have life cycles with alternation of generations. Unlike bryophytes and pteridophytes, spermatophytes do not have free living gametophyte; instead the gametophyte is attached to and nutritionally dependent upon the sporophyte generation. Seed plants are divided into two groups based on whether or not their ovules are protected. One group is called **gymnosperms**. They produce seeds that are totally exposed or borne on the scales of cones. The other group, **angiosperms**, are flowering plants that produce their seeds within a fruit.



Fig. 7.6 Fruit and seed

Seed bearing habit has many advantages for seed plants (such as protection, food and dispersal). This character has played a primary role in the success of these plants. We find that the two groups of seed plants, gymnosperms and angiosperms, exhibit the greatest evolutionary complexity in the plant kingdom and are the dominant plants in most terrestrial environments.

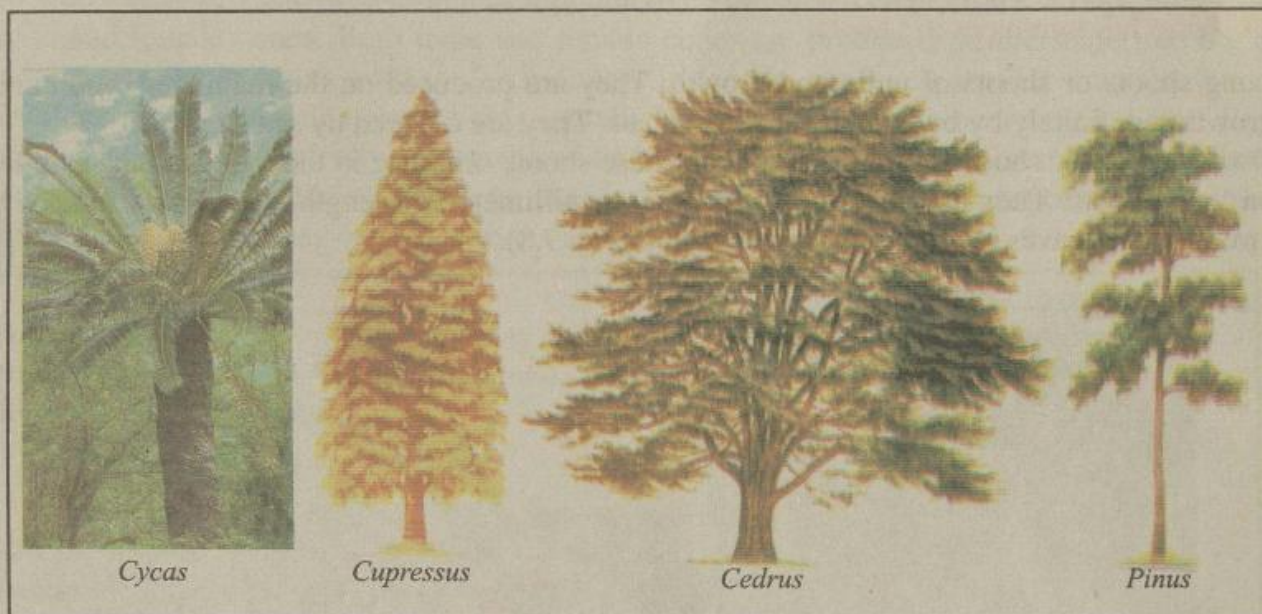


Fig. 7.7 Different types of gymnosperms

7.3 Gymnosperms

Gymnosperms (gymno- naked, sperm- seed), as already mentioned, are naked seeded vascular plants. With a few exceptions all gymnosperms are evergreen woody trees or shrubs that show secondary growth (chapter 2). Their wood or secondary xylem contains tracheids. Vessels which are present in angiosperms are absent from the wood of most gymnosperms. That is why their wood is called “soft wood”.

Gymnosperms are divided into four groups but the largest and the most familiar group is called **conifers**. They are called conifers because their seeds are borne on woody scales arranged to form a cone.

One of the oldest and the largest forests of Junipers in the world are found at Ziarat in Baluchistan. Realizing the threat of their extinction, government of Pakistan with the collaboration of U.N.O has taken actions to save this national heritage. The measures taken include supply of gas to the local people to meet the needs of fuel, which they used to fulfil from this forest.

Gymnosperms are mainly found in colder regions or at high altitudes. In hilly areas of Pakistan there are luxuriant forests of conifers. Some of the conifers found in our northern areas (Murree, Kaghan, Gilgit etc.) include *Pinus* (chir or kail or chilgoza), *Abies* (fir), *Cedrus* (cedars, deodar) and *Juniperus* (juniper, snober).

7.3.1 *Pinus* and *Thuja* - the typical gymnosperms

Pinus is normally found growing at an altitude of 5000ft to 8000ft. However, some species can be grown in the plains. *Pinus* tree is a sporophyte, which is evergreen and quite tall. It consists of an extensive root system and a strong, stout and woody stem and its branches. The upper

branches progressively become shorter in length so that the tree assumes a symmetrical conical appearance.

Thuja (commonly known as Mor Pankh) is a short; conical tree grown as ornamental plant in parks and homes. It has profuse branches, which are covered with small, dark green scale leaves.

Pinus has two types of shoots:

1. Long shoots or shoots of unlimited growth. They are produced on the main stem and continue growth indefinitely by buds borne at their apices. They are covered by scale leaves.
2. Dwarf shoots or shoots of limited growth. These shoots originate in the axles of the scale leaves on long shoots. They are very short (only a few millimeters in length). Each dwarf shoot bears 1 to 5 foliage leaves in addition to scale leaves (Fig. 7.8).



Fig. 7.8 Shoots of gymnosperms

Some of the most interesting and strange members of the plant kingdom belong to the gymnosperms. For example, a giant sequoia (*Secquoiadendron giganteum*), known as General Sherman tree, is world's most massive organism. It is 82m (272ft) tall and has a girth of 23.7m (79ft) measured at 1.5m (5ft) above ground level.

Another gymnosperm, a coast redwood (*Sequoia sempervirens*) is probably the world's tallest tree, measuring almost 117m (385ft) in height.

One of the oldest trees, a bristle cone pine (*Pinus aristata*) in the White Mountains of California, has been estimated to be 4900 years old!



General Sherman tree

In Pinus there are two types of leaves:

1. Scale leaves which, are small, membranous and brown in colour. They cover the stem.

2. Foliage leaves or Needles. These are commonly long and narrow, tough, and leathery. In contrast to scale leaves, they are green and photosynthetic. Depending upon the species, a cluster of 2 to 5 needles is borne on each dwarf shoot. Each dwarf shoot with its cluster of needles is called a **spur**. *Thuja* has small scale-like green leaves that cover the stem.

At every season, *Pinus* tree produces reproductive structures called **cones**. Cones are of two kinds, male and female cones. Both male and female cones are produced on the same tree but on different branches. Male cones, usually 1 cm or less in length, are much smaller than the female cones. They are produced in clusters and are generally borne on the lower branches of the tree. Each male cone is composed of spirally arranged leaf-like structures called **scales** or **microsporophylls**. Each microsporophyll consists of two long sacs called **pollen sacs** or **microsporangia**. Asexual reproductive cells, microspores or pollen grains are produced through meiosis in the microsporangia asexual.

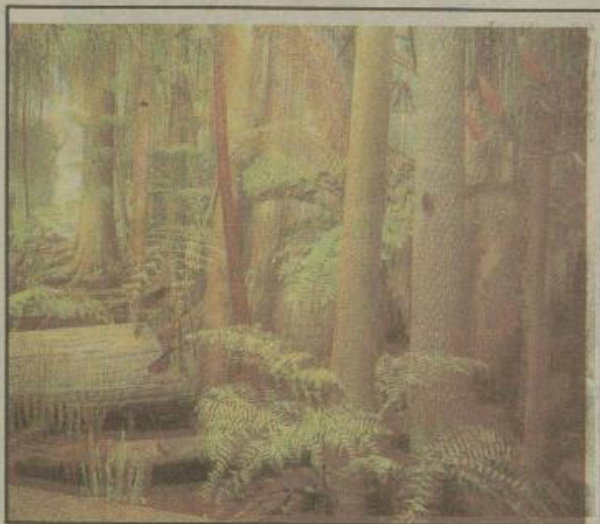
Pollen grains are haploid. After being transferred to the ovule, the pollen grain forms pollen tube, which is the male gametophyte. Male gametes or sperms are produced in it.

The more familiar female cones are much larger than the male cones and are usually found on the upper branches. Each female cone is also composed of spirally arranged scales called **megasporephylls**. These scales become woody when mature. Two ovules are present side by side at the base of each scale. Haploid megaspores are formed in the ovule by meiosis. Megaspores give rise to female gametophyte which produce female gametes. Fertilization results in embryo formation after which the ovule ripens to form seed. Female cones normally remain attached for three years on the plant. When mature the cones open up and the seeds are set free and dispersed.

In *Thuja*, the female cones are spherical or oval in shape and about the size of a bairst (berry). They consist of hard, brown colour scales with triangular apices.



Fig.7.9 Gymnosperm cones



The modern industrial society depends on the energy from fossil fuels i.e., coal, petroleum and gas. The remains of the plants (including mainly ferns and gymnosperms), which lived about 300 million years ago, were partially decomposed into organic material and buried under the layers of sediments. With time, heat and pressure built up in the accumulated layers and converted the organic material into coal.

Practical Work: Study of shoot, leaves and cones of *Pinus*.

1. Observe a *Pinus* shoot.

There are two types of branches and two types of leaves in *Pinus*. A dwarf shoot along with its needles is called a "spur".

- How many needles are there in the spur which you are studying?
- ### 2. Observe a male cone. It is about an inch in length and consists of scales or microsporophylls, which are arranged spirally on an axis.

3. Examine longitudinal section of a male cone under a dissecting microscope.

- What do you observe on the underside of each scale?
- Do you see any grains inside these sacs?

These sacs are called pollen sacs. Pollen grains or microspores are produced in them by meiosis.

4. Place a scale in a drop of water on the glass slide. Tear the pollen sac with the help of a needle. Place a cover slip over it and observe the pollens under the microscope.

- What do they look like?

Draw their figure.

- What do you think is the function of the wings, which are present on the sides of the pollen grains?



Male cone



Microsporophyll



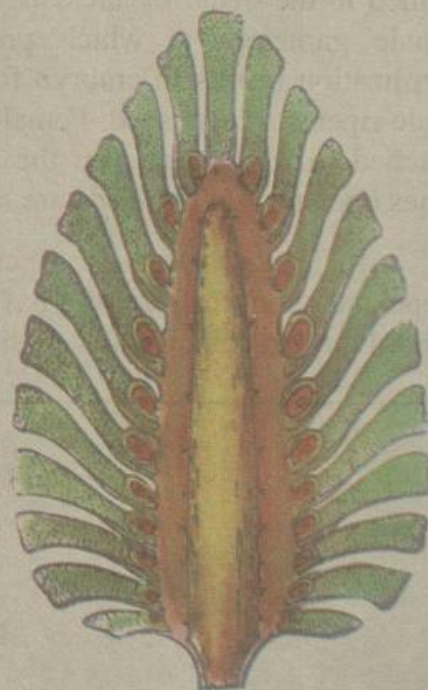
Pollen grain



Pollen sac
or microsporangia



Megasporophyll
and ovules



Female cone

Fig. Male and female cones in *Pinus*

7.3.2 Importance of Gymnosperms

Gymnosperms are important to humans in many ways:

1. They produce timber (e.g., deodar wood from *Cedrus*, kail or chir from *Pinus*), which is excellent building material. Their wood is also used for making furniture and paper products.
2. Many useful medicines are obtained from them. For example, anticancer drug taxol is obtained from *Taxus*. *Ginkgo* has been an important medicinal plant for centuries. Extract from its leaves may increase blood flow to the brain. *Ephedra* is the source of ephedrine, which stimulates the heart and raises blood pressure.
3. Many conifers yield turpentine and resins.
4. Because of their attractive appearance, many gymnosperms such as *Cycas* (Kangi palm), *Thuja* (Moor Punkh), *Cupressus* (saroo) and *Araucaria* are grown as ornamental plants in homes, parks and alongside roads.

7.4 Angiosperms

Angiosperms are most successful plants. They surpass even the gymnosperms in importance. They have adapted to almost every type of environment and with at least 235,000 species they are earth's dominant plants.

Angiosperms are vascular plants that bear flowers. Their seeds are produced within fruits. The fruit protects the developing seeds and also aids in their disperse. Seed and fruit producing habit has helped flowering plants in their evolutionary success.

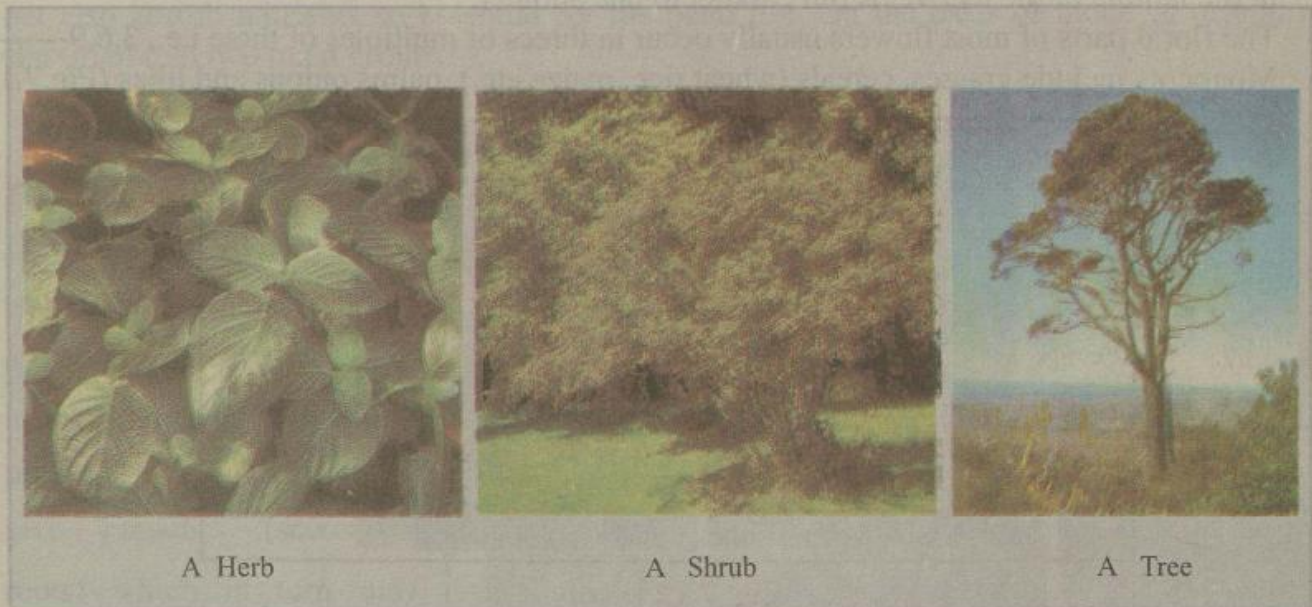


Fig. 7.10

Flowering plants are found in wide variety of sizes and forms. In size they range from over 300 ft in height (some species of *Eucalyptus*) to scarcely 1mm in length (duckweed, *Wolffia*). On the basis of size and woodiness, angiosperms may be classified as herbs, shrubs (bushes) and trees. Herbs are small in size. Their stems are not hard and woody and wilt when cut or pulled from the soil. On the other hand shrubs and trees have hard woody stems, which retain their shape even after being cut. Shrubs are shorter than trees but have proportionately greater spread. In addition to tracheids, angiosperms possess efficient water conducting structures called vessels in their xylem.

7.4.1 Classes of Angiosperms

On the basis of the number of cotyledons in the seed, flowering plants are divided into two classes; the monocotyledons or monocots and dicotyledons or dicots.



Fig.7.11 Monocots

1. Monocots.

Monocot seeds have a single cotyledon or embryonic leave. A nutritive tissue called “endosperm” is usually present in the mature seed.

Monocots are mostly herbaceous plants with long narrow leaves that have parallel veins i.e., in the lamina of the leaf veins run parallel to one another.

The floral parts of most flowers usually occur in threes or multiples of three i.e., 3,6,9-----.

Monocots include grasses, cereals (wheat rice, maize etc.), palms onions and lilies (Fig.7.11).



Fig. 7.12 Dicots

2. Dicots.

Two cotyledons are present in the dicot seed and the endosperm is usually absent in the mature seed. Their leaves vary in shape but usually are broader than monocot leaves. Leaves have netted veins i.e., branched veins resembling a net.

The flower parts are four or five in number or multiples of 4 or 5. Dicots include rose, peas and pulses, sheesham, kiikar (Acacia), sarsoon (mustard), cacti, mango, orange and sunflower etc (Fig.7.12).

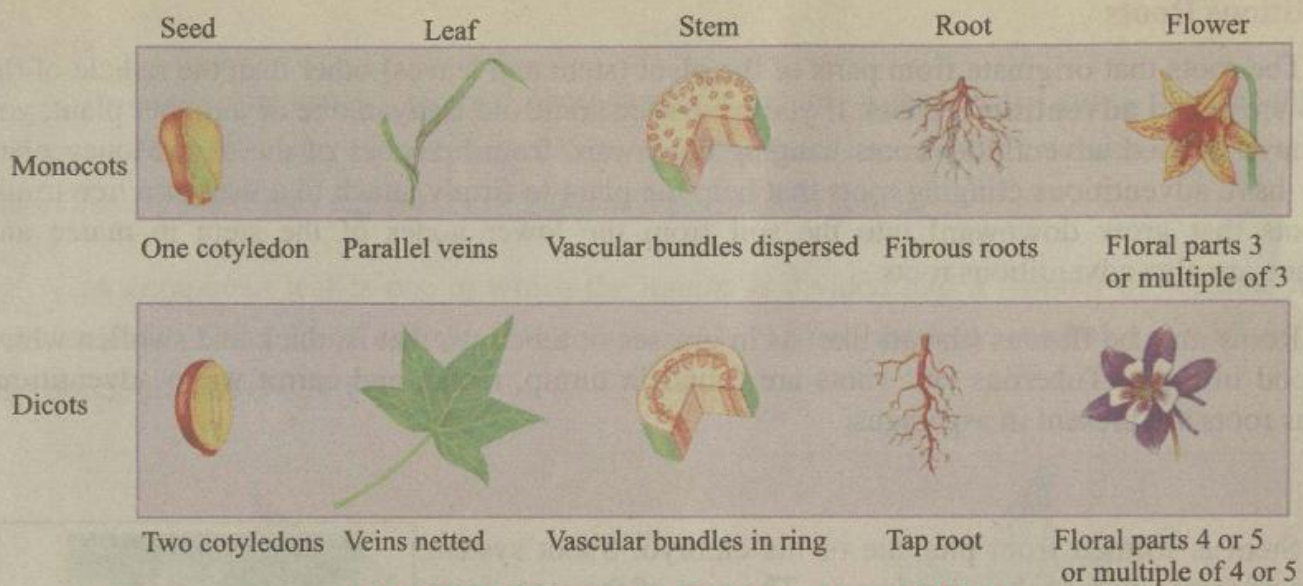


Fig. 7.13 Differences of monocots and dicots

7.4.2 Plant Body of Angiosperms

You studied a typical angiospermic plant - *Brassica campestris* in chapter 2. Recall that *Brassica* plant which consists of roots, stem and leaves, is an independent free living sporophyte.

Roots.

Roots are the underground part of the plant. They not only anchor the plant firmly in the soil but also absorb nutrients so essential for the plant life. On the basis of mode of origin, roots are classified into two main groups.

1. Tap roots
2. Adventitious roots.

Tap Root

The first root, which is formed by the elongation of the radicle of the embryo in the seed, is known as the **primary root**. This may give branches (**secondary roots**) which in turn may produce other branches (**tertiary roots**). If the primary roots persists and becomes thicker than its branches, it is known as the tap root.

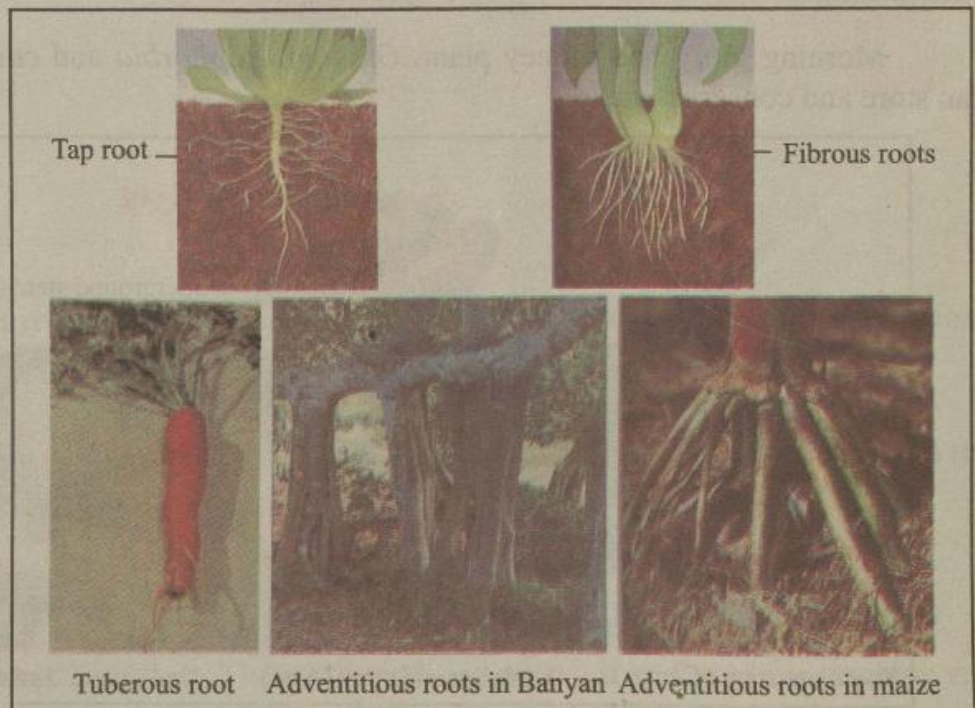


Fig. 7.14 Different types of roots

Adventitious Roots

The roots that originate from parts of the plant (stem and leaves) other than the radicle of the embryo are called **adventitious roots**. If you have seen some old Banyan tree or a rubber plant, you might have noticed adventitious roots hanging downward from branches of the tree. Money plant and Ivy have adventitious clinging roots that help the plant to firmly attach to a wall or a tree trunk. The roots that grow downward into the soil from the lower nodes of the stem in maize and sugarcane are also adventitious roots.

Roots may be fibrous (thread-like) as in grasses or tuberous, that is, thick and swollen which store food in them. Tuberous tap roots are found in turnip, radish and carrot while adventitious tuberous roots are present in asparagus.

Stem

Stem is formed from plumule of the embryo. Shoot system consists of stem, its branches and leaves. The part of the stem from which a leaf arises is called a **node**, while the region between two successive nodes is known as **internode**. Apices of stem and its branches bear buds, by which the stem continues its growth (Fig.7.15).

Mostly, stem is aerial and grows upward but some stems are subterranean and are called **underground stem**. Underground stems usually store food in them. Ginger, potato, turmeric and arvi are some examples of the underground stem (Fig. 7.16). Some stems called **weak stems** are so weak that they can not grow erect and, therefore, spread on the ground or climb up the neighbouring objects. Weak stems are found in vines, cucurbits (gourds, melons, cucumbers),

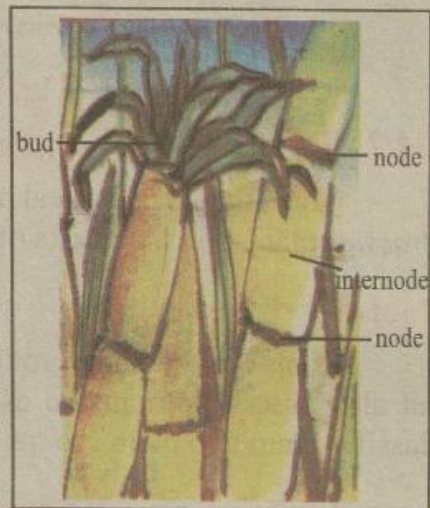


Fig. 7.15 The shoot stem

Morning glory and money plant. *Opuntia*, *Euphorbia* and *cactus* have succulent stems that can store and conserve water.

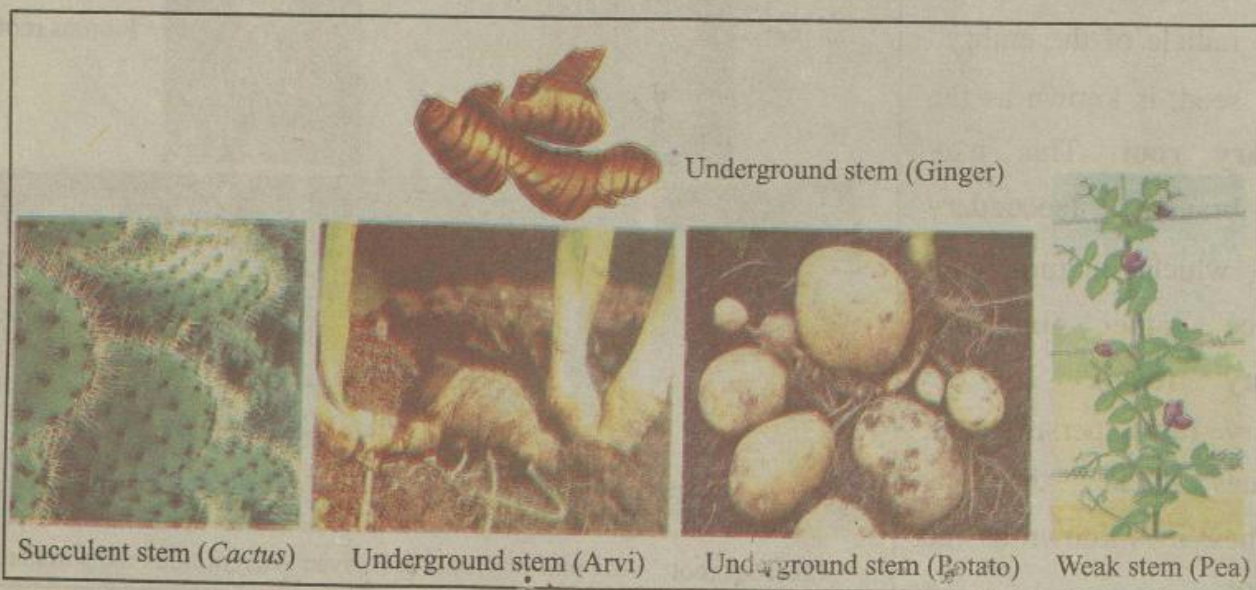
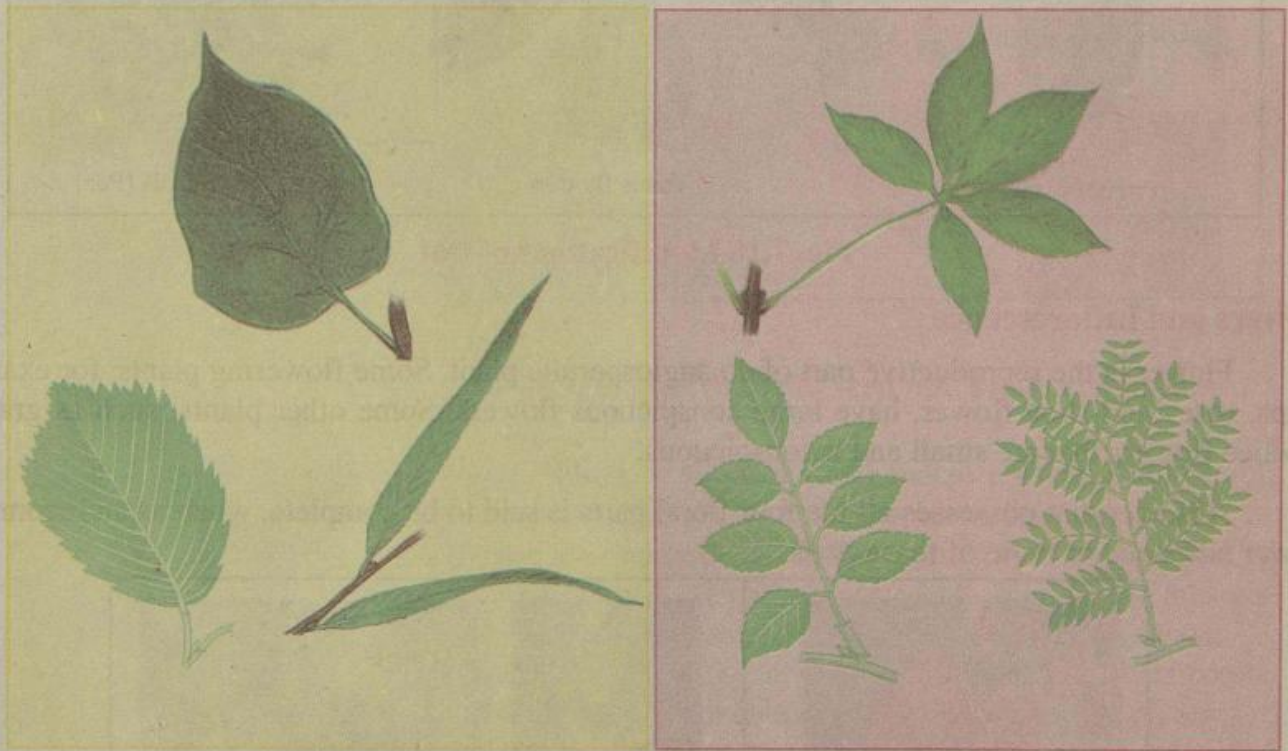


Fig. 7.16 Different types of stem

Leaves

As you know leaves are chief photosynthetic organs of the plant. Leaves may be stalked or without stalks. They may be simple or compound. The leaves in which the lamina is all in one piece are called simple leaves e.g. leaves of mulberry, peepal and cotton.

A compound leaf is one in which the lamina is divided into a number of separate leaf-like parts called leaflets. Some examples of compound leaves are amaltas, sumbal, rose, kikar (acacia) and dhrek (*Melia*) (Fig.7.17).



Simple leaf

Compound leaf

Fig. 7.17 Types of leaf

Modifications of Leaves:

In many plants the leaves are wholly or partially modified to carry on special functions (fig.7.18). Some examples of modified leaves are;

1. **Leaf tendrils**-In this case the leaf is modified into wire-like coiled structure that help the plant in climbing some objects as in pea.
2. **Leaf spines**-For protection as in barberry.
3. **Leaf pitchers and leaf bladders**-These are modified forms of leaf used for catching and digesting insects. Examples include insectivorous plants such as "pitcher plant", "Venus fly trap" and "bladderwort".

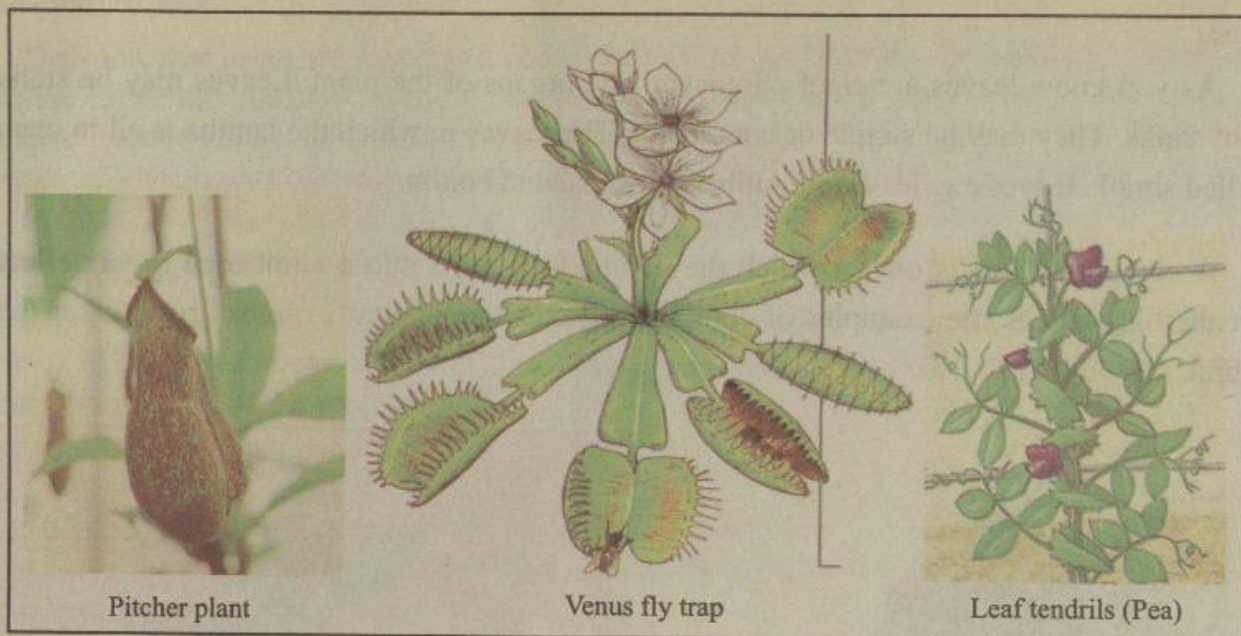


Fig. 7.18 Modifications of leaf

Flowers and Inflorescence

Flower is the reproductive part of an angiospermic plant. Some flowering plants, for example tulips, roses and shoe flower, have large conspicuous flowers. Some other plants, such as grasses, produce flowers that are small and inconspicuous.

A flower that possesses all the four floral parts is said to be **complete**, whereas an **incomplete** flower lacks one or more of these parts.

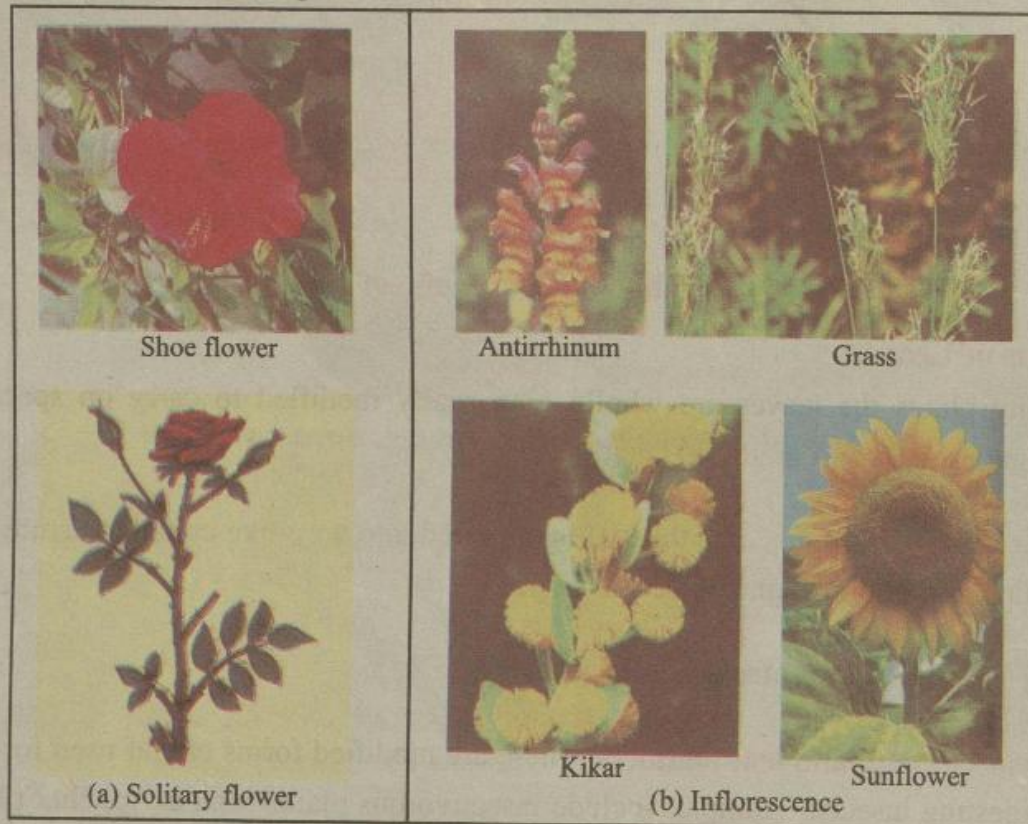


Fig. 7.19 Solitary flower and Inflorescence

Flowers may occur singly on flowering axis. Such flowers are called **solitary flowers** e.g. rose and shoe flower. In most cases, however, flowers are aggregated together. A group of flowers having a special arrangement on the flowering axis is called **inflorescence** (Fig.7.19).

Seed, which is produced as a result of fertilization and subsequent growth, contains young plant (an embryo) and nutritive tissue (the endosperm), both of which are surrounded by a protective seed coat. By the time seed develops from an ovule following fertilization, the ovary enlarges dramatically and develops into a fruit. Once a seed lands at a suitable place, it may germinate and develop into a mature sporophyte that produces flowers and the life continues (Fig.7.20).



Fig. 7.20 Flower, fruit, seed and seed germination

Importance of Angiosperms

1. Many angiosperms are source of food. Wheat, rice, grams and maize are our staple food. Pulses and millet (bajra) which are our food items belong to angiosperms.
2. Many important constituents of our food are obtained from angiosperms. For example olives, canola, mustard, coconut, maize, sunflower and oil palm yield edible oils. Sugar and gur (brown sugar) is obtained from sugar-cane and beetroot. All these plants are angiosperms.
3. Vegetable such as radish, carrot, turnip, peas, cabbage, gourd, pumpkin, beans, bitter gourd, ladyfinger (okra), tomato, onion, garlic and ginger are obtained from angiospermic plants.
4. Many plants such as different grasses, sorghum (jawa, chari), trifolium (barseem), herbs and tree leaves are source of fodder for animals.
5. Delicious and nutritional fruits such as mango, apple, pear, apricot, peaches, melons, banana, coconut, dates, kino and malta etc. come from angiosperms.
6. Many useful products, which serve as medicines, are obtained from them. For example, peppermint is obtained from mint, dillseeds (Ajwain) from *Thymus*, gulkand and scent from rose, a type of laxative from Amaltas (*Cassia*) and quinine from Cinchona.
7. Timber is obtained from a number of angiospermic plants. Sheesham wood is considered excellent for making furniture. Wood of certain other angiospermic plants such as mulberry and willow is used in making sports goods.
8. Angiosperms also provide wood for burning. For example, wood of sheesham, jund, sirrus and kikar is used as fuel.
9. Fiber for making ropes and linen is obtained from many angiosperm plants such as cotton and jute.
10. Many angiosperms because of their bright colours, fragrance, attractive appearance and beautiful leaves are grown as ornamental plants. Salvia, petunia, marigold, dahlia, zinnia, rose, jasmine, shoe flower, chandani, gladiolus, tulips and narcissus are a few examples.
11. Large angiospermic trees such as banyan, peepal etc. provide shade and shelter to animals.

KEY POINTS

1. In contrast to bryophytes, the tracheophytes:
 - i) Possess vascular tissues
 - ii) Sporophyte is prominent and dominant phase whereas gametophyte is reduced.
2. Pteridophytes do not produce seeds whereas spermatophytes are seed producing vascular plants.
3. Plant body in ferns consists of an underground rhizome, fronds and adventitious roots. Fronds are large leaves which are often compound.
4. Young leaves in ferns are rolled inwards. This condition, which is recognition of the ferns, is called circination.
5. Seed and fruit producing habit has played important roll in the evolutionary success of the spermatophytes because these structures provide protection and nutrition to the embryo.
6. In gymnosperms the seeds are naked and are often borne on scales.
7. Xylem in gymnosperms contains only tracheids whereas angiosperms have vessels in addition to tracheid.
8. Gymnosperms are source of timber, medicines, dry fruit and resins. They are also grown as ornamental plants.
9. Angiosperms are divided into monocots and dicots. Monocots have one whereas dicots have two cotyledons.
10. Roots can be classified into two groups-tap roots and adventitious roots. Tap root originates from the radicle while adventitious roots arise from stem and leaves.
11. Sometimes the stem and the leaf are modified into different structures for performing special functions.
12. Most of the flowers are small and inconspicuous and are arranged in the form of groups. This special arrangement of flowers on the flowering axis is called inflorescence.
13. Seed consists of a young plant (embryo), stored food and protective cover.

QUESTIONS

1. Fill in the blanks:

- i. Gymnosperms and angiosperms are also called ----- because both produce seeds.
- ii. Rolling of young fern leaves is called -----
- iii. Monocot leaves are usually long and -----vein in them.
- iv. Fern gametophyte is also called -----.
- v. From the under surface of the fern rhizome -----roots are produced.
- vi. The tissue which provides nutrition to the embryo is called -----.

2. Each question is provided with four options, encircle the correct one.

- i. Which of the following is not the difference between monocots and dicots?
 - (a). Leaves of dicots are usually broad
 - (b). Flower parts in monocots are usually two or multiple of two.
 - (c). Monocot stem normally do not show secondary growth.
 - (d). Vascular bundles in monocot stem are arranged in the form of a cylinder.
 - (e). Dicot embryo has two cotyledons.
- ii. Roots of angiosperms
 - (a). Always form fibrous root system
 - (b). Have root cap at their apices
 - (c). Usually carry out photosynthesis
 - (d). Give out branches from lateral buds

(e). Do not have secondary growth

iii. Which statement is not true for ferns?

(a). Sporophyte is larger than gametophyte.

(b). Frond is a large leaf.

(d). Gametophyte is dependent upon the sporophyte.

(e). Adventitious roots are produced from the rhizome.

iv. Which statement is not true for gymnosperms?

(a). At present they are the most dominant plants on land.

(b). They show secondary growth.

(c). They have vessels in their xylem.

(d). They are usually found in plains.

v. Which statement is not true for the flowers?

(a). A group of flowers is called an inflorescence.

(b). A flower having all the four parts is called a complete flower.

(c). Most of the flowers are large, prominent and solitary.

(d). Stamen is a reproductive part of the flower.

3. Answer the following question in brief:

i. Describe any two characteristics of tracheophytes which distinguish them from angiosperms and gymnosperms.

ii. The presence of embryo, seed and fruit indicates which group?

iii. What is the basic difference between sporophyte and gametophyte?

iv. Define tap root and adventitious root.

v. Define alternation of generations.

4. Compare the characteristics of different groups of tracheophytes.

5. Describe differences between monocots and dicots.

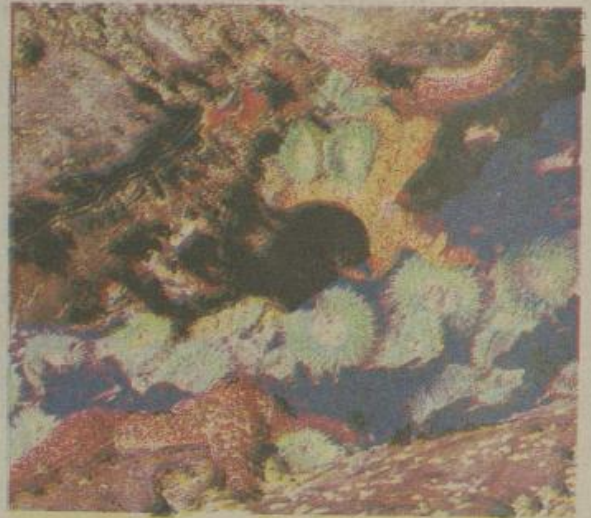
6. Describe importance of gymnosperms.

7. In what ways angiosperms are important for us?

INVERTEBRATES

In this chapter you will learn:

- Common characters of animals.
- Classification of animals on the basis of common characters.
- Differences between various animal's groups.
- Division of invertebrates into groups.
- Identification of animals from Protozoa to Echinodermata on the basis of distinguishing characters.



Invertebrates is that group of animals which do not possess vertebral column in their body. More than twelve million kinds of invertebrate animals are present on the earth. According to two kingdom classification invertebrates are divided into nine major groups (phyla). This division is based on their similarities and differences. From protozoa to phylum echinodermata, every phylum has its own distinguishing characteristics on the basis of which they can be identified.

8.1 Protozoa

According to two kingdom classification protozoa is the first phylum of invertebrate animals but according to five kingdom classification it is placed in a separate kingdom, "protista" in which all other eukaryotic unicellular organisms are also placed. Body of all protozoans is composed of one cell and are thus called **unicellular**. They are so small in size that they can not be seen with naked eye but can be seen with the help of a microscope. Although they are unicellular but they are capable of performing all life activities e.g. intake of food, respiration, reproduction etc. Protozoans mostly live in damp, watery places. Their habitat is mostly moist soil, decaying matter of animals and plants. Most of them live singly but some form colonies. In a colony, unicellular organisms become partially interdependent and limit themselves to perform specific functions in a group. If separated from group they still can perform all life activities and can live independently. Some protozoans are parasites and cause diseases. For example a type of *Amoeba* causes dysentery, *Plasmodium* is responsible for malaria disease. Protozoans are also useful for man because they feed and destroy bacteria which are harmful for human health for example *Amoeba* can feed on bacteria. Some protozoa living in sea water for example Foraminifera secrete a calcareous shells around themselves which, on their death are deposited at the bottom of sea forming chalk. This is used in making toothpowder and black board chalk. *Amoeba*, *Plasmodium* and *Paramecium* are common examples.

Paramecium

It is found in pools and ponds. It has slipper shaped, body covered with cilia. Cilia are small hair like out growths originating from protoplasm. Their controlled lashing movement in water acts as oars and help in swimming (locomotion) of the animal. Paramecium feeds on algae, bacteria and other small protozoan, through an oral groove provided with cilia. Cilia push food inside the protoplasm through a canal called gullet making a food vacuole in the protoplasm. There are two contractile vacuoles, one at each end of the body for discharging surplus water (osmoregulation). This animal possesses two nuclei one large, mega or vegetative nucleus which regulates all activities, other small, micro or reproductive nucleus controls reproduction.

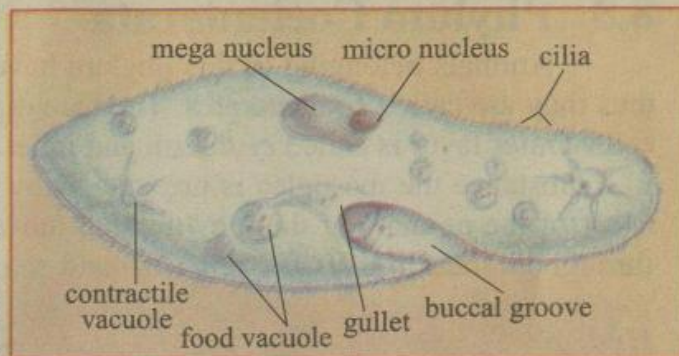


Fig. 8.1.1 *Paramecium*

Many protozoa like *Amoeba* and *Paramecium* are unicellular but they respond to intensity of light like other multi-cellular organisms. They can detect high intensity of light and move towards the area having low intensity of light.

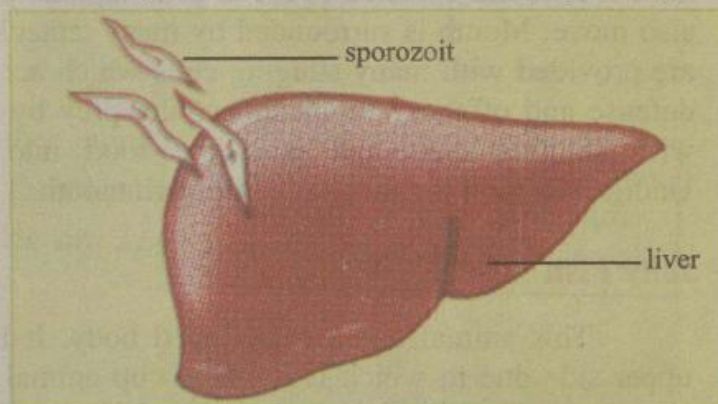


Fig. 8.1.2 *Plasmodium sporozoit*

8.2 Phylum Porifera

This phylum is called porifera because animals belonging to this phylum have numerous small pores on their bodies. They are generally called **sponges**. These animals are multicellular. They have no organs or true tissues and even their cells shows a certain degree of independence. Every cell performs its all functions. These are aquatic animals. Most of them are found in sea water but some live in fresh water. Sponges have different colours. Green colour of sponge is due to algae that live in their body. Algae produce oxygen during photosynthesis which is used by sponges and the sponges release carbon dioxide, which is used by algae for photosynthesis. This is a type of association in which both the organisms benefit from each other. Such an association of two different organisms is called **mutualism**. Sponges may live singly or may form branched colonies. These are sessile i.e. they cannot move and remain attached to stones and rocks. Numerous small canals are present in their body. Water passes through these canals providing food and oxygen to the body cells. Cells also excrete their waste and carbon dioxide in this water. Sycon is an example of marine sponge while spongilla is an example of fresh water sponge.

Sycon

This animal lives as long branch colony. These branches originate from a base. It has a skeleton made up of calcium carbonate. The body is flexible but strong and remains attached to the rocks.



Fig. 8.2.1 *Sycon*

In glass sponges skeleton is siliceous due to which it looks very shiny

8.3 Phylum Coelenterata

Animals belonging to this phylum have a special cavity in their body called **coelenteron** and thus they are called **coelenterates**. They are diploblastic animals having in their bodies two layers of cells. Outer layer is called ectoderm and inner layer is called endoderm. Between these layers a jelly like substance the mesoglea is present. Many animals are marine but some also live in fresh water. Most of the animals of this phylum can move freely but a few remain attached to stones or rocks throughout their life. *Hydra*, jelly fish and sea anemone are common examples.

Hydra

It is a fresh water animal with a body size of 6 to 10 millimeters. When contracted it can extend its body upto 30 mm. It is found attached to rocks or to aquatic plants but can also move. Mouth is surrounded by many tentacles. Tentacles are provided with many stinging cells which act as organs of defense and offence. Tentacles capture prey by paralyzing it with stinging cells and push the food into the mouth. Undigested food is also egested through mouth.



Fig. 8.3.1 *Hydra*

Jelly Fish

This animal has a cup shaped body. It has a convex upper side due to which it is called cup animal. It ranges in size from 2 to 40 cm. It is exclusively marine. Body is transparent and is thus not easily visible in water. Its shape is like an open umbrella. The mouth is centered on the lower side of the body at the end of a triangular structure called **manubrium** which is drawn out to form frilly oral arms with tentacles at their margin. Small floating animals (plankton) present at the surface of water are taken in as food with the help of tentacles. Jelly fish is found floating near the surface of water.



Fig. 8.3.2 *Jelly fish*

Some jelly fish are very large in size with their tentacles reaching from 60-70 meters in length

Corals are the coelenterates living in the limy skeletal cup (exoskeleton) which is secreted by the epidermis. After the death of animal, their skeletons which are made up of calcium carbonate are deposited at the bottom of shallow tropical seas, which later accumulate over thousands of years to form rock like deposits known as **coral reef**. These are commonly found under water but as a result of geological changes it may come up above the water surface. Coral reefs are commonly formed near the islands where water is shallow. Some times it causes accidents in sea.



Fig. 8.3.3 *Coral reef*

8.4 Phylum Platyhelminthes

These are triploblastic animals because their body is composed of three layers, an outer ectoderm, a middle mesoderm and an inner endoderm layer. They are also known as flat worms because their body is thin, flattened and tape like. Some are free living but most are parasite.

Parasites live in liver, stomach and intestine of other animals. They attach themselves to the walls of intestine of their host by sucker and suck blood and food. Common examples are *Liver fluke*, *Tape worm* and *Planaria*.

Liver fluke

It is a parasite. It has a leaf like structure. It lives in lungs, liver, stomach and intestines of its host. At the anterior end of the body an oral sucker is present around the mouth. A sucker is also present at ventral side of the body by which it firmly attaches itself to the body of the host. It sucks food through oral sucker. The tissues of the body parts from where it sucks food are damaged producing ulcer or wounds. Persons suffer from anaemia due to blood sucking which may sometimes lead to death. It has two parts of its life cycle. One of its parts is passed in man, sheep or goat and the other in the body of a snail. This parasite has two hosts one is man, sheep or goat and other is snail.

Tapeworm

It is also a parasite. Its body is long, tape like and segmented. Head is slightly larger than body and is called **scolex** which bears suckers and hooks. It attaches itself to the walls of intestine through suckers. The head does not have eyes. It can not move. New segments

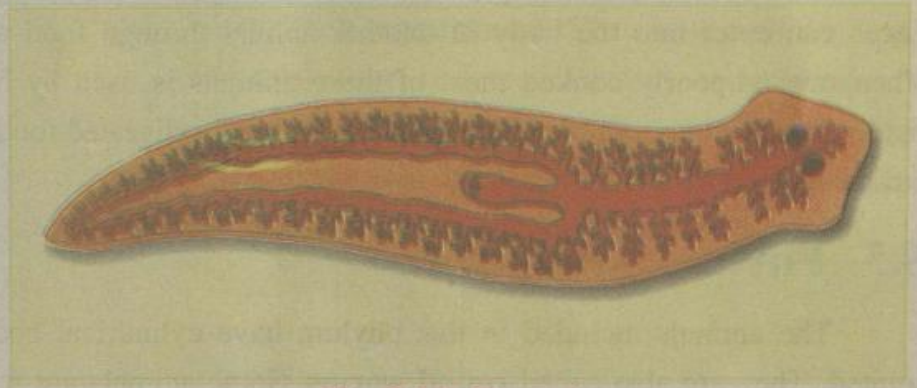


Fig. 8.4.1 *Planaria*

Tape worm sucks food from intestine and sometimes grows up to 40 feet in length.

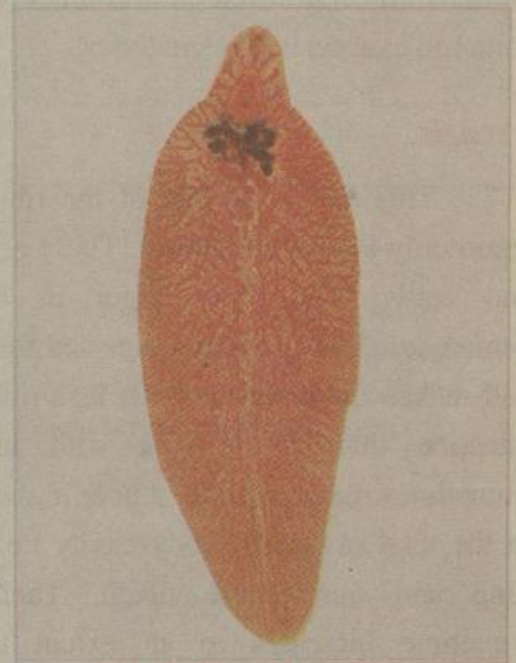


Fig. 8.4.2 *Liver fluke*

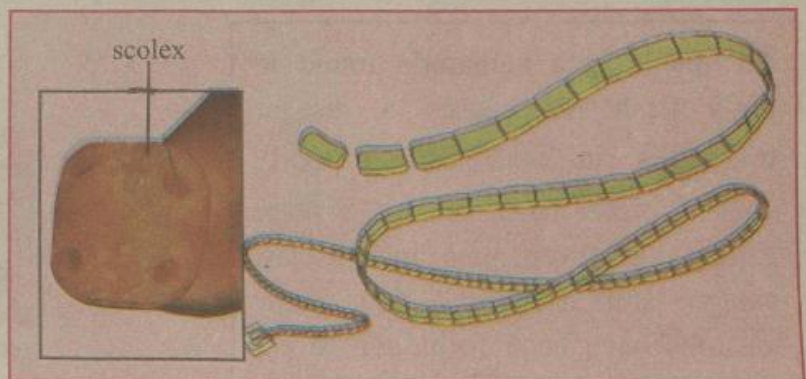


Fig. 8.4.3 *Tapeworm*

arise at the posterior side of the head and the older segments are pushed away, which ultimately detach from the body of the tapeworm and are expelled out of the human host. These detached pieces can enter into the body of another animal through food and reach the muscles and liver. When raw or poorly cooked meat of these animals is used by healthy man, the parasite grows inside the intestines and becomes an adult. It absorbs digested food of man through its general body surface.

8.5 Phylum Nematoda

The animals included in this phylum have cylindrical bodies with both ends of the body pointed. They are also called **round worms**. Some animals are free living and others are parasite. Digestive system in both i.e. free living as well as parasitic, is tubular with a mouth at the anterior and an anus at the posterior region.

Free living nematodes inhabit the upper layer of soil, freshwater or sea water. The parasites produce different diseases in human beings. *Ascaris*, hook worm, *Filaria* and *Trichinella* are some common examples of nematodes.

Ascaris

This animal is one of the roundworms and is commonly known as **malap**. These are present in man and cattle. They are larger in size than other nematodes. They suck the digested food from intestine and makes the body weak. It lays millions of eggs in intestine that are voided with undigested food. Sometimes *Ascaris* makes a hole in the intestine, enters in the vital organs of body cavity i.e. liver, heart and lung and may cause death. Their number may sometime increases to an extent that intestine is blocked which may lead to death.

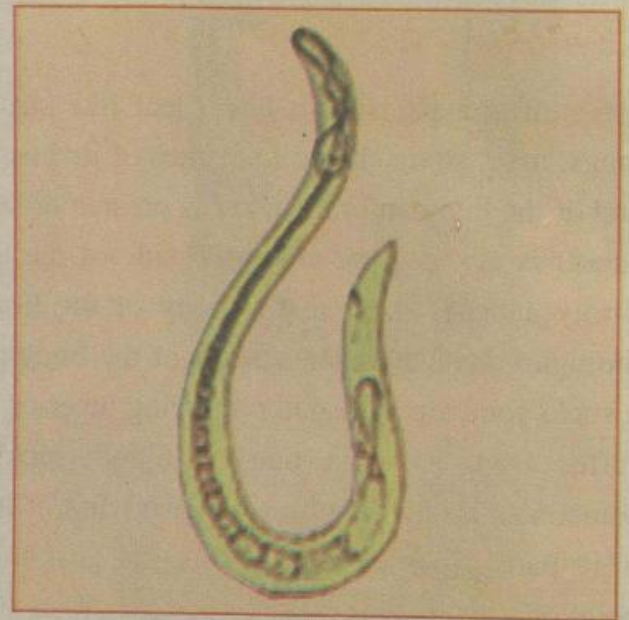


Fig. 8.5.1 *Ascaris*

Trichinella is a nematode found in pig's flesh. This causes a disease trichinosis in man eating poorly cooked pig's meat. In this disease patient has fever, pain in muscles, nausea and dysentery. You know muslims have been forbidden to eat pig's meat.

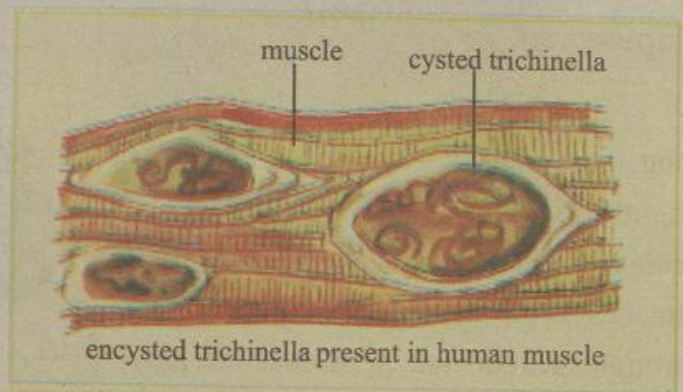


Fig. 8.5.2 *Trichinella*

8.6 Phylum Annelida

Animals included in this phylum are found in moist-soil, ponds, river, and sea. Their bodies have external and internal segmentation called **metameric segmentation**. They have well developed digestive, circulatory, excretory, nervous and reproductive system. Excretory and reproductive systems are repeated in every segment and nerve cord, the big blood vessels and alimentary canal extends from one end to the other. Most of the animals are free living. Some like leech lives as ecto parasite. Earthworm and Neries are common examples of this phylum.

Leech

It is an ectoparasite found in pools and ponds etc. Body is segmented. A sucker is present around the mouth and other at the posterior end. Through its oral sucker it can suck the blood of buffaloes and other animals that may visit the ponds.



Fig. 8.6.1 Leech

In villages people use leech to suck their so called bad blood from diseased area of the body. This may lead to serious consequences because leeches are found in dirty, muddy water and may be infested with pathogens.

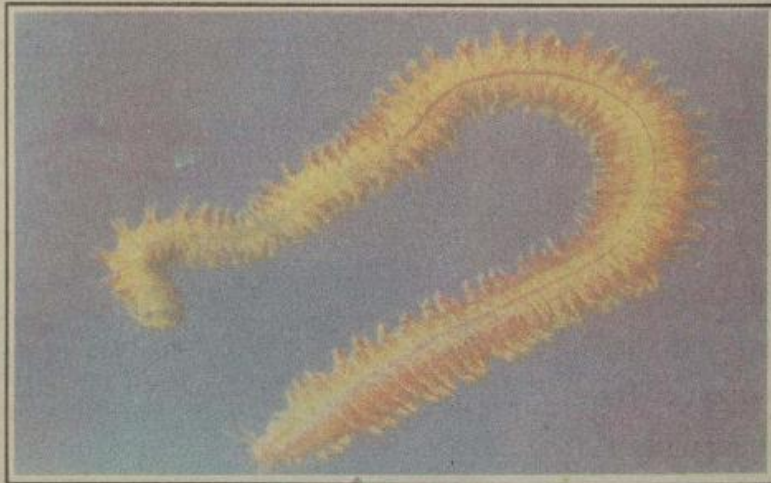


Fig. 8.6.2 Neries

Earthworm

It is found all over the world, living in the burrows. It is elongated, cylindrical and segmented animal with a body length from 10 to 20 cm. Anterior end is pointed while posterior end is slightly broad. Its skin is thin and moist through which exchange of oxygen and carbondioxide gases takes place because no proper respiratory system is present. It lives in the humus rich upper layer of soil and swallows the soil. It uses the decaying organic matter as food and soil is expelled out of the body as worm's casting on the soil. It thus brings the deep lying fertile soil to the top which improves the fertility of the land. It is, therefore, called farmer's friend.

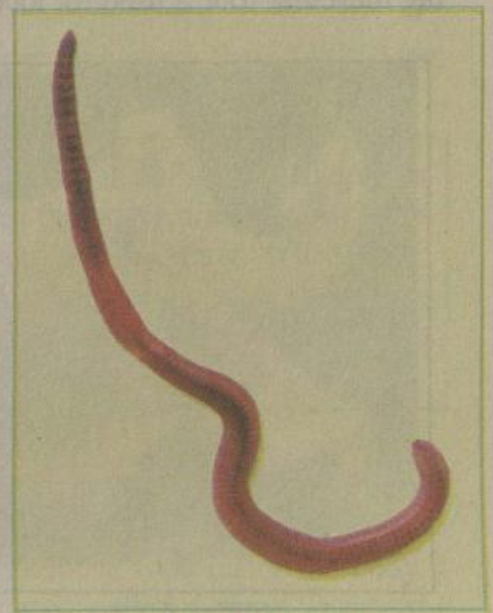


Fig. 8.6.3 Earthworm

8.7 Phylum Mollusca

This phylum is one of the largest phyla of animal kingdom. It has about fifty thousand species. Mollusca, a Latin word means 'soft'. Their body is soft so in most of the animals an external shell is present for support and protection. Some animals have internal shell and some are without shell. They are also called **shell fish**. They are found in aquatic and moist habitat. Most of them are used as human food. Buttons are made from their shell and pearls are produced by these animals. Their body is quite complicated. They have a muscular foot for locomotion and gills for respiration. *Snails*, *Fresh water mussel*, *Cuttle fish*, *Octopus* and *Oyster* are common examples.

Fresh water mussel

This animal is about 8 cm in length, 2-3 cm thick, 4-5 cm broad and is laterally compressed. It is enclosed in two pieced calcareous shell. Body is soft and thick with a ventral muscular foot for locomotion. It is found on the banks of ponds, streams and rivers.



Fig. 8.7.1 Fresh water mussel

Snail

Some of its species live in damp places and in gardens. Most of the species are marine. They range in size from microscopic to 60 cm in length. Its body is enclosed in a calcareous coiled shell. This shell has many compartments, last one is the largest and snail lives in it. It has two tentacles bearing two eyes. The **radulla**, a tongue like structure is used for feeding. A big muscular foot is used for locomotion.

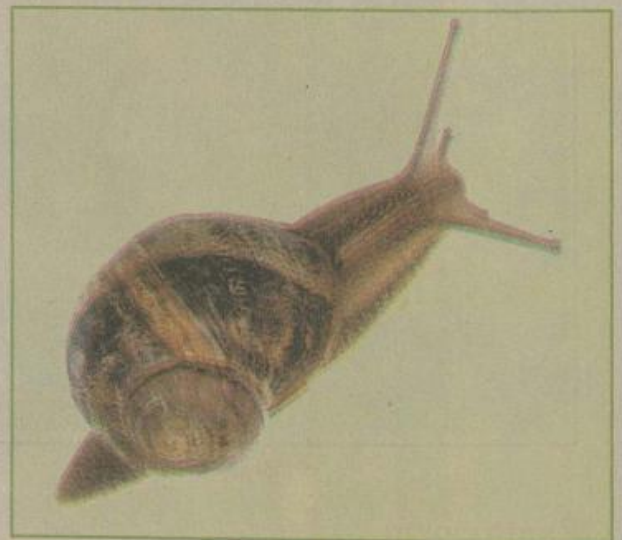


Fig. 8.7.2 Snail



Fig. 8.7.3 Octopus

Formation of pearl

When an irritating parasitic worm or sand particles enters in the body of oyster, its shell forming tissues "mantel" secretes many layers of shell forming matter around this foreign body forming pearl. This pearl forming process is completed in years.

8.8 Phylum Arthropoda

The bodies of these animals are also segmented but these segments are external. Their bodies are covered with the hard shell made up of chitin, forming an exoskeleton. Jointed legs are present on their body and thus they are named as arthropoda, (**arthro** means jointed and **poda** means foot). These animals are found in all habitats, in air, water and on land. Common examples are prawn, crab, spider, scorpion, centipede, millipede and insects.

One third of this phylum consists of insects. Their bodies are externally divided into three segments head, thorax and abdomen.

In addition three pairs of legs, two pairs of wings are also present for flying. Two prominent antennae are present on head. House fly, mosquito, butterfly, grasshopper are examples of insects.

Some arthropods possess four pairs of legs on their body as spider, scorpion etc.

Some arthropods are worms with elongated bodies. Their bodies are divided into many segments. Each segment has one or two pairs of legs, for example centipede and millipede.

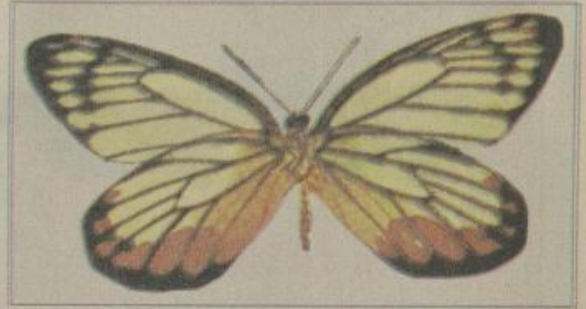


Fig. 8.8.1 Butter Fly



Fig. 8.8.2 Spider



Fig. 8.8.3 Centipede

Metamorphosis

Arthropods pass through various stages of development before they reach their adult stage. This process is known as metamorphosis. This process is of two types.

1. **Complete metamorphosis**
2. **Incomplete metamorphosis**

Honey prepared by honey bees is at first thin like water but it becomes thick when the water dries. Honey bees move their wings rapidly to dry the water. When water evaporates honey becomes thick and dense, the honey bees seal the cells in which honey is present by the bee's wax.

Complete metamorphosis

This process of complete metamorphosis can be observed in the life cycle of housefly, mosquito, butterfly etc. This process completes in four stages, egg, larva, pupa and adult. The larva hatches from the egg, eats and moves about. After storing a lot of food inside the body it becomes inactive and develops a covering around body and now it is called a **pupa**. Inside the

capsule further developmental changes occur in the pupa. After a few days an adult animal comes out of the pupa which resembles the parents.



Fig.8.8.4 Complete metamorphosis

Incomplete metamorphosis

In the process of incomplete metamorphosis three developmental stages are present viz., egg-nymph-adult. Young after hatching from the egg is called **nymph**. It is like an adult apparently missing wings and reproductive organs. It becomes an adult animal after the development of wings and reproductive organs. It can be seen in the life cycle of cockroach.

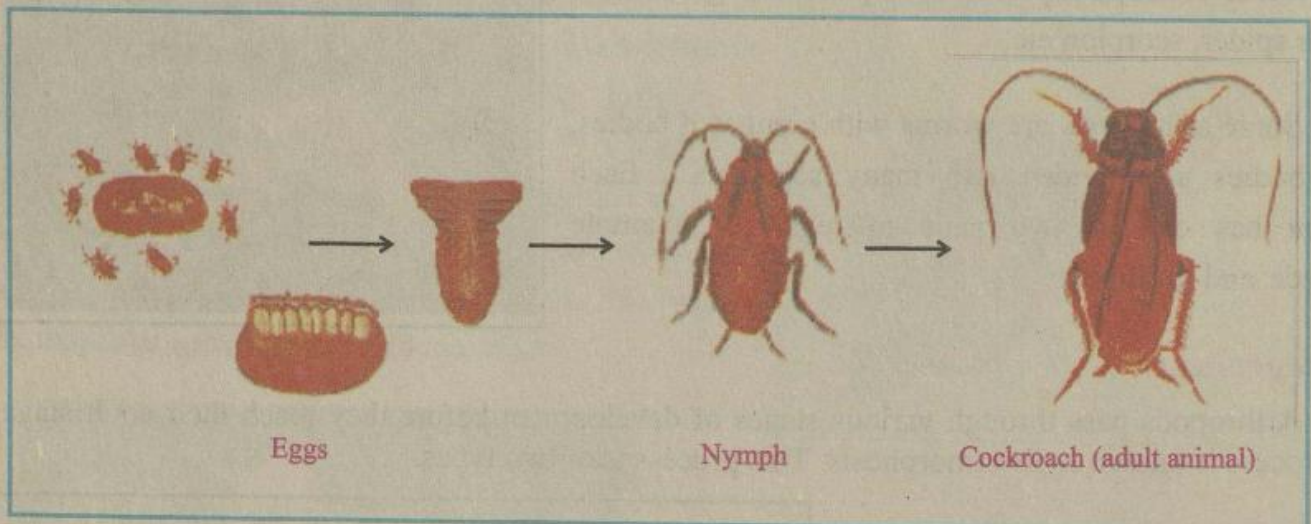


Fig. 8.8.5 Incomplete metamorphosis

8.9 Phylum Echinodermata

The animals of this phylum are exclusively marine. These animals are unique. They are called echinoderms because bodies are covered with spines or spicules. All animals have internal skeleton consisting of dermal calcareous ossicles. They have a water vascular system and dermal gills. These animals are considered to be closest to the chordates from evolutionary point of view. Sea star (known as star fish), brittle star, sea urchin and sea cucumber are examples of this phylum.

Star Fish

Actually it is not a fish. Its body is star shape. The central part of the body is disc like from which arms originate. Mouth is on the ventral side of the disc. There are many tube feet on the ventral side of each arm with the help of which it moves about or attaches itself to the rocks. It has a strong power of regeneration.

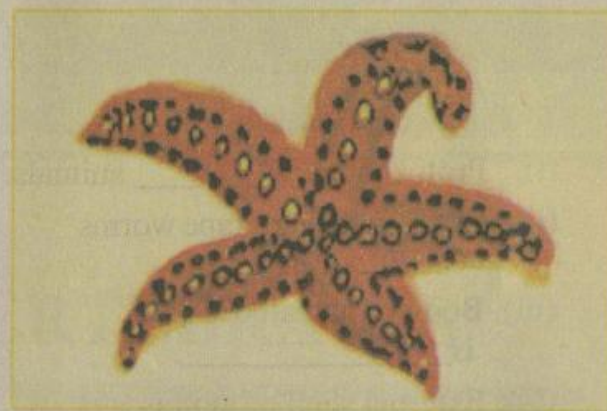


Fig. 8.9.1 Star fish

Sea Urchin

It has a rounded body with long spines. Its body has skeleton made up of many calcareous plates. Mouth is on the ventral side of the body and have five teeth. It lives at the bottom of sea (bottom dweller).



Fig. 8.9.3 Brittle Star



Fig. 8.9.2 Sea urchin

Star fish have five arms but some have more.
Star fish is mostly active at night and lays millions of eggs.

KEY POINTS

1. Vertebral column is not present in the body of invertebrates.
2. Invertebrates are divided into many groups.
3. Protozoan are unicellular. They mostly live singly.
4. Porifera have small pores on their body. These are sessile i.e they cannot move.
5. Coelenterates are diploblastic animals. Tentacles are present around the mouth.
6. Bodies of animals belonging to phylum platy helminthes are thin, flat and ribbon like with three layers of cells in their bodies.
7. Nematodes are mostly parasites. Their body is round and elongated. Digestive system is in the form of an elongated duct. (canal).
8. Bodies of annelids are externally and internally segmented many systems are found in their bodies.
9. Bodies of molluscs are soft, non segmented and covered with a hard shell. A soft and muscular foot is present in the body for locomotion.
10. Arthropods are animals with jointed legs. They are found in all habitats i.e. water, earth, air.
11. Echinoderm are totally marines. From the evolutionary point of view they are close to the chordates.

QUESTIONS

1. Fill in the blanks.

- (i). Protozoa are _____ animals.
- (ii). Liver fluke and tape worms are _____
- (iii). Body of nematodes is _____.
- (iv). External shell of molluscs is made up of _____.
- (v). Echinoderm means _____ skin.

2. Identify the true/false statements.

Also correct the false statements.

- (i) Coelenterates are aquatic animals.
- (ii) Planaria are free living.
- (iii) Body of earthworm is non-segmented.
- (iv) Snail lives in dry places.
- (v) Arthropods have two pairs of legs.

3. Each question is provided with four options, encircle the right one.

- (i). Animals of which phylum can't move.
(a).Coelenterata (b).Porifera
(c).Echinodermata (d).Protozoa
- (ii). Animals of which phylum are diploblastic.
(a).Platyhelminthes (b).Coelenterata
(c).Nematoda (d).Annelida
- (iii). From the following which one is ectoparasite.
(a). Hook worm (b).Tape worm
(c). Leech (d).Earth worm
- (iv). Which one has jointed legs.
(a).Arthropoda (b).Annelida
(c).Nematoda (d).Mollusca
- (v). Animals of which phylum are totally marine.
(a).Mollusca (b).Arthropoda
(c).Porifera (d).Echinodermata

4. Give short answers to following questions.

- (i). Name two protozoans that produce diseases in man.
- (ii). Why phylum porifera is given this name.
- (iii). What is mesoglea.
- (iv). Which name is given to the locomotory organ in snail.

- (v). Which type of animals are close to chordates from evolutionary point of view?

5. (i). Describe in detail the characters of protozoa.

- (ii). Write a note on paramecium.

6. (i). Write down the specific characters of animals belonging to phylum coelenterata.

- (ii). Write briefly about a jelly fish.

7. What is meant by parasite? Write notes on any two parasites that you have studied.

8. (i). Describe the specific characters of animals of phylum Annelida.

- (ii). Describe briefly an earthworm.

9. (i) Write down the characters of Arthropods.

- (ii). What is meant by metamorphosis? Discuss its various types.

10. (i). What are the special features of phylum Echinodermata?

- (ii). Briefly describe star fish and sea urchin.

CHORDATES / VERTEBRATES

In this chapter you will learn:

- Diagnostic characteristics of chordates.
- Difference between lower chordates and higher Chordates / vertebrates.
- Salient characteristics of five classes of vertebrates.



Chordates is that group of animals whose embryos or larvae always possess following three characteristics. Some chordates retain these characteristics throughout their life.

1. Notochord

This rod like structure is made up of semi-rigid body of cells that is enclosed in a sheath of connective tissues. It is located dorsal to the alimentary canal and ventral to the central nervous system running from anterior to posterior end. Its major function is to provide support and stiffens the body. It act as skeletal axis. In most of the animals, notochord is replaced by a back bone.

2. Pharyngeal Pouches

Pharyngeal pouches are present at some stage in life cycle of the chordates. Pharyngeal pouches develop into gill slits in the adult animals that live in water and breath by gill. While in the animals that live on the land these pouches are replaced by other organs. e.g inner part of ear etc.

3. Hollow Dorsal Nervous System

In all chordates a hollow dorsal nervous system is present, whose anterior part enlarges into brain. Postanal tail usually projecting beyond the anus is present at some stage in life.

Among the chordates, "vertebrates" is the largest group. There are more than 47 thousand species of vertebrates on the earth. Vertebrates have been divided in to five different classes. This division is based on the similar and different characteristics that are helpful to identify their separate classes. Common characteristic of all vertebrates is the presence of vertebral column in their body. It is present in the mid dorsal part of the body running from anterior to posterior end. It has small vertebrae which are joined together. The anterior end of the vertebral column is box like and called **cranium**, which protects brain and it enlarges with the development of the body.

Vertebrates have been divided into five classes, Pisces, Amphibia, Reptilia, Aves, Mammalia.

9.1 Class Pisces

Fishes

According to their size and shape, the fishes are of many kinds. They have a head, a trunk and a tail, head and trunk are directly jointed together and neck is absent. Body of fish is flexible tapering at both ends and streamlined. So that it can easily wade through water during swimming. They can swim with fins, which are attached to the trunk. The body is covered with scales which remain moist by special type of secretion of body. Breathing organs are gills which are present in the hollow spaces found on both sides of the head for exchange of gases i.e oxygen and carbon dioxide.

Mouth has teeth, which are used for grasping instead of grinding of food. In some fishes air pouch is present, which is called air bladder. The air bladder is used for buoyancy. Fishes are **cold blooded** animals. They can not maintain their body temperature and their body temperature varies with that of their environment. Some fishes have bony skeleton. In bony fishes gills are covered with the **operculum**. Common examples are *Labeo rohita*, carp, cat fish. Some fishes have cartilaginous skeleton. Their gills are not covered with operculum. These are marine. Common examples are shark, dog fish. skate and rays.

Labeo rohita (Rohu)

It is found in fresh water and is herbivorous, with a body length of 2-3 feet. Mouth is present on the ventral side. Teeth are absent in jaws. A single gill opening is present at both sides of the head, which is covered with the operculum. Its body is covered with scales but scales are absent in the head region.

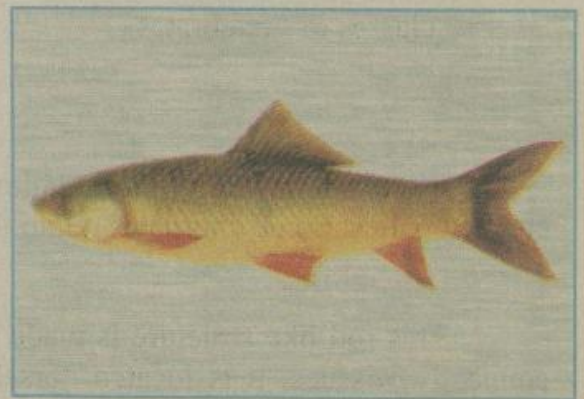


Fig. 9.1.1 Rohu



Fig. 9.1.2 Shark

Some fishes live singly. Some live in groups called school. In fishes pupil size is large as compared to other vertebrates. Which permits more light. Fishes have no eyelids.

9.2 Class Amphibia

Amphibians

Animals belonging to this group can live both in water and on land. Their body is covered with thin and loose skin. The skin is moist and slimy. Small teeth are present in the upper jaw which are only used for grasping the prey. Breathing organs are lungs. Skin is also used for the exchange of gasses. Eggs are laid in water or moist places and their outer shells are not hard. Common

examples are frog, toad and salamanders. These are cold blooded animals. They cannot maintain their body temperature constant. When it is extreme cold they become very slow and they bury themselves in the mud. This process is called **hibernation**. During the process of reproduction fertilized egg is transformed into adult passing through a number of physical changes. This transformation process is called **metamorphosis**. The fertilized egg develops into larva which have tail and gills. This larva later changes into adult.

Frog

Rana tigrina is a common species found in Pakistan. Its skin is moist and slimy. Dorsal body surface has green patches and ventral side is yellowish. Two protruding eyes with immovable eyelids are present. Eyes have a transparent nictitating membrane, which can spread over eye to protect it. Hind limbs are long and powerful and help it to hop and swim. A membrane is stretched between the five digits of hind limbs. This helps the frog in swimming. Digits are not provided with nails. Smallest frog in the world is found in Brazil. Its length is less than 1 cm. World largest frog is found in West Africa whose body length is upto 30 cm. It feeds on rats, ducks etc.

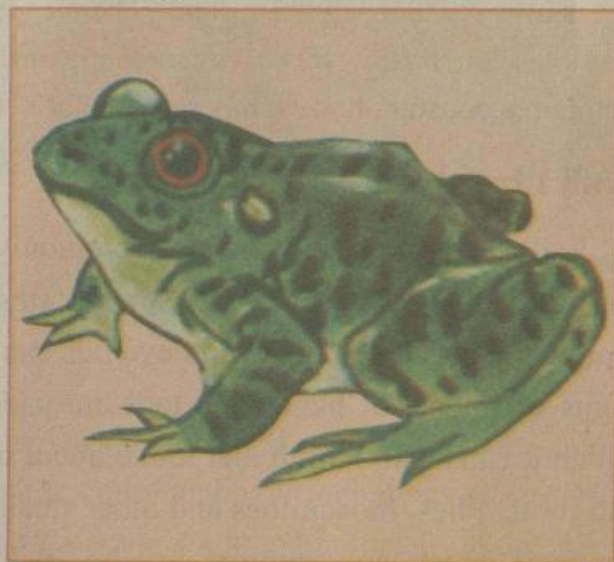


Fig. 9.2.1 Frog



Fig. 9.2.2 Toad

Toad

Its skin is dry and rough. It lives on land but it has to go in water to lay eggs. Its life cycle resembles with that of frog. There are no teeth present in the mouth.



Fig. 9.2.3 Salamander

During hibernation frog's heart beat and temperature decreases they respire once in five minutes. It is impossible to wake up the animal. In extreme hot season frog again bury itself in the mud and becomes immovable. This process is known as estivation.

9.3 Class Reptilia

Reptiles

Most of the animals belonging to this group are terrestrial. A few live in water. They are also called **crawlers**. They have thick, dry and rough skin covered with scales. The scales originate from

the ectoderm. Respiration takes place through lungs. Teeth are present in their buccal cavity, which are used for cutting and biting. The locomotary organs are legs but snakes and a few types of lizards have no legs. Most of the lizards are not poisonous except members of the genus *Heloderma* which are found in American deserts. All the reptiles lay their eggs on land. Water dwelling reptiles e.g. turtles also lay their eggs on land. Their eggs have a tough outer shell of calcium carbonate. The examples are lizard, snake, chameleon, turtle and crocodile. These are cold blooded and cannot maintain a constant body temperature, that's why lizard and snakes etc. hibernate during winters.

Wall Lizard

It is a domestic Lizard commonly found in houses. Its body is covered with small scales. It has two prominent eyes on the head and eye lids can move. The digits or fingers of hands and toes are padded, due to which it can easily climb and move about on the walls and roofs. Flies, mosquitoes and other small insects are its food which are captured by the sticky tip of its tongue

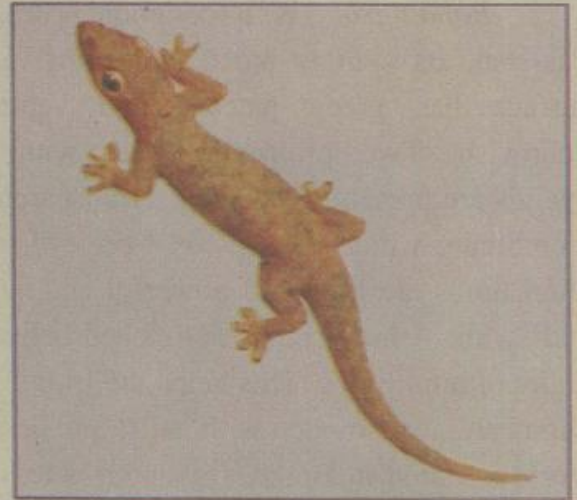


Fig. 9.3.1 Wall lizard

Snake

It lives both in water and on land. Its body is long and cylindrical. Its eyes are permanently covered with transparent membrane called spectacle and eyes are immovable to a great extent. It can't blink its eyes which produce horrifying effect on the onlookers. External and middle ears are absent in snake due to which people consider it as deaf. In snake, however, internal ear is present. It has been recently discovered that it can hear sounds of low frequency and can receive the vibration carried in the earth. Snake uses its chemical senses to hunt its prey. In addition to the usual olfactory areas in its nose two pits are present in palate called **Jacobson's organs**. These snakes detect their prey by its heat. In viper snake special heat sensitive pits are present on their head between the nostrils and the eyes. It can distinguish even very low temperature difference. There are many species of snakes but only 1/3 of these are poisonous. Non-poisonous snakes catch and kill their prey and then engulf them. Their food consists mainly of rats, fishes, frog, insects and eggs of other animals. The body of snake is covered with scales. It can open its mouth to a large extent and can swallow a prey of even larger than its body size. Poisonous glands are present in its mouth. It injects its poison through its upper teeth, which are long and curved with canals inside them leading from the poisonous glands. Most snakes lay eggs but some give birth to their offspring.



Fig. 9.3.2 Snake

Chameleon has a very long tongue and thus can capture the prey from quite a distance.

Some snake like Garter and Copper head keep their shelled eggs in their body which hatch inside the body and thus "lay" their young ones.

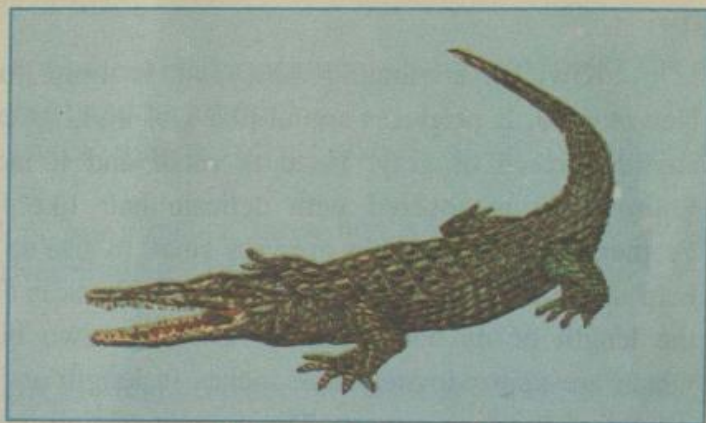


Fig. 9.3.3 Crocodile

9.4 Class Aves

Birds

All the birds are included in class Aves. It is the most studied and most observable class in the world. The organisms included in this class are very beautiful and have melodious voices. More than 9000 species of birds are distributed over the entire earth and are found in forests, in deserts, on the mountains, in the valleys & near oceans of all world, (four species were found near North pole and one species was sighted near South pole). Some birds live in the dark caves where they track their way by the echolocation. Some birds can dive up to 45 meters down in the ocean to catch their food, mainly fishes. Birds have a single unique feature, which makes them different from other animals that is the presence of feathers. Furthermore, the forelimbs are adapted to form wings while hind limbs help in walking, wading and sitting on the branches. All the birds have horny beaks and they all lay eggs. There is thus a great uniformity of structure among birds. The most probable reason for this great structure and functional uniformity is that birds evolve into flying machine. This fact seems to have greatly restricted diversity in birds which is so much more elegant in other vertebrate classes. Birds share with mammals the highest organ system development but their entire is designed around flight and its perfection. All the birds must have two wings for support and propulsion and strong but light, hollow bones. Their digestive system is able to digest high caloric food. They have a higher blood pressure and higher metabolic rate. Nervous system and specially eye sight is very well developed so that they can track their path even at a very high speed, as birds migrate during winters towards warmer places covering thousand of miles.

Birds are divided into two groups.

1. Running Birds (Ratitae)

Running birds have flattened sternums and their pectoral muscles are less strong.

Examples are Ostrich, Emu, *Rhea*, *Cassowary*.

Kiwi

Kiwi is a running bird and is only found in Newzealand. It produces sound like kivi kivi. Its colour is slightly brown or gray. Head is small and it lacks tail. Entire body is covered with delicate hair like feathers. Feathers on the fore limbs are very small in size so can not help in the flight of animal. The length of beak is one third the length of its body. Female kiwi lays two big eggs, which are approximately five inches in length and have a weight of fourteen ounces. The amount of yolk present in kiwi's eggs is more than in any other bird's egg.



Fig. 9.4.1 Kiwi

2. Flying Birds (Carinatae)

In these birds keel is present on sternum. It is a vertical bony part that is present below the sternum in the centre from anterior to posterior end. Pectoral muscles are very strong, powerful and are inserted on the keel. These muscles help them to fly. Their common examples are pigeon, hen, crow, kite etc.

Pigeon

It is present almost everywhere e.g in rocks, cervices, house walls, in ventilators and roofs. It occurs in many varieties. It's body is divided into head, neck, thorax and tail. It's body is spindle shaped. This structure decrease air resistance during flight. Its body and legs are covered with feathers. Digits are provided with scales.



Fig. 9.4.2 Pigeon



Fig. 9.4.3 Humming bird

Humming bird is the smallest bird in the world. It is only two inches long. Its weight is about three grams.

Ostrich can run 70 km or 42 miles/hour.

9.5 Class Mammalia

Mammals

Highly advanced animals are included in class mammalia. It has almost four thousand species. Man is also a mammal.

Following are the distinguishing characteristics of mammals

1. Their body is covered with hairs. In most of the mammals hairs may cover the whole body but in a few may be restricted to some areas.
2. Their skin is provided with sweat glands, scent glands, sebaceous glands and mammary glands.
3. Two occipital condyle, secondary bony palate, three bones in middle ear and fused pelvic bones and seven cervical vertebrae are present in their skeleton.
4. Fleshy external ears.
5. Moveable eyelids are present.
6. Two sets of teeth are present. Milk-teeth are replaced by permanent set of teeth.
7. Brain is highly developed.
8. Twelve pairs of cranial nerves are present. Circulatory system has four chambered heart, persistent left aorta and non-nucleated, biconcave red blood corpuscles are present.
9. Sexes are separate.
10. Most of them has internal fertilization and fetus developed inside the uterus of female giving birth to their children.
11. They feed the children by milk from mammary glands.
12. They are endothermic i.e they can maintain their body temperature according to the environment.

Mammals are divided into three groups.

1. **Egg laying mammals**
2. **Pouched mammals**
3. **Placental mammals**

All mammals are hetrodonts. Their different types of teeth perform different functions. They are used for cutting, piercing or grinding. While all the remaining vertebrates have single type of teeth.

1. **Egg Laying Mammals**

These mammals lay eggs. Mostly two eggs are laid in one year. Fertilization of eggs is internal i.e. inside the body of mother. Eggs are laid in burrows of animals. Young ones are hatched from the eggs. Mother feed their children with milk e.g. Duck bill platypus and Spiny ant eater. Their egg laying character shows their relationship with reptiles.



Fig. 9.5.1 Duck bill platypus



Fig. 9.5.2 Spiny ant eater

2. Pouched Mammals

These mammals have a pouch outside the belly, called **marsupium**, so they are called marsupial mammals. Fertilization of eggs and development of embryo is internal. The embryo is at first encapsulated by shell membrane and floats free for several days in the uterine fluid. After hatching from the shell membranes, the embryo does not implant or "take root" in the uterus and absorbs nutrient secretions from the vascularized yolk sac. The gestation period is brief and the marsupials give birth to tiny young that is effectively still an embryo. These young creep into the marsupium where it gets milk from mother through nipple. It lives in marsupium until it can take care of itself, examples are kangaroo, koala, tasmanian wolf and wombat etc. These are found in Australia and Tasmania. Opossum is found in America. It lives on trees.



Fig. 9.5.3 Kangaroo



Fig. 9.5.4 Koala

3. Placental Mammals

In placental mammals embryo completes its development inside the mother's uterus. After gestation period young ones are born. Embryo remains in the uterus and gets its nourishment from mother through umbilical cord and placenta. Gestation period of these mammals is longer than those of other mammals.

Gestation period varies from animals to animals. In mice it is 21 days, in Rabbit 30 to 36 days, in cats and dogs 60 days, in cattle 250 days and in elephants 22 months.

Some mammals e.g. bear undergo winter sleep during winter. During this their heart beat and respiration process slow down. During winter sleep they use reserve food materials of their body.

Winter sleep and hibernation differ in the sense that during winter sleep animals wakeup during mild days and then undergo sleep while during hibernation it is impossible to wake it up.

The conditions of young ones of various mammals at birth is different for example in antelope, at the time of birth, the body of young is covered over with heavy fur, eyes are open and it can walk about while young of rat is very weak, eyes are closed and have no hair on the body.

Placental mammals have 19 orders some are given below.

(i) Insect eating mammals

They eat insects and are nocturnal in habit. Hedgehog, shrew and mole are common examples.



Fig. 9.5.5 Mole

(ii) Edentate mammals

Their nails are long and strong with the help of which they dig burrows to live in. They eat worms, insects and ants with the help of their tongue. Front teeth (incisors) are very small or absent. Sloth, armadillo and pangolin are common examples..



Fig. 9.5.6 Pangolin

(iii) Rodent mammals

Their incisors are sharp and pointed. Their food consists of vegetables, fruits, seeds and leaves. These animals eat their food by gnawing with teeth. Common examples are rabbit, mouse, squirrel etc.

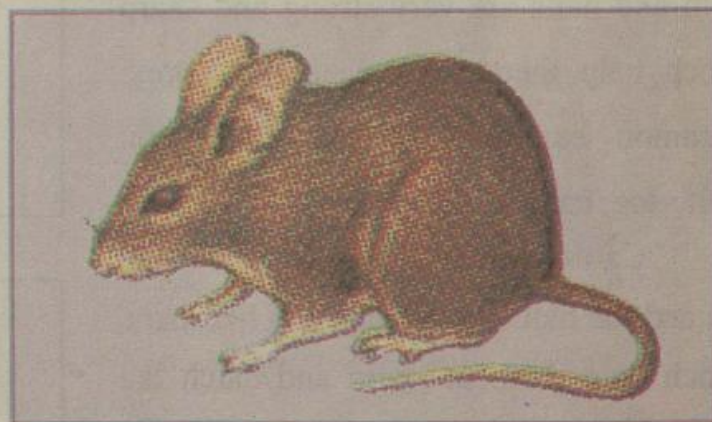


Fig. 9.5.7 Mouse

(iv) Flying mammals

These mammals can fly. Their fore limbs are modified into wings in which 2nd to 5th digits are elongated to support a thin integumental membrane for flying. They are nocturnal in habit. Their sense of hearing is well developed, common example is bat.



Fig. 9.5.8 Bat

(v) Hoofed mammals

These are herbivore mammals. They are ruminants. The fore and hind limbs are provided with hoofs. Common examples are camel, horse, cow, buffalo, bull, goat, giraffe and zebra etc.

(vi) Trunked mammals

In these mammals upper lip and nose becomes long to form a trunk. They are biggest animals on land. They are herbivore. Trunk is used to take food and water to mouth. Common example is elephant.

(vii) Carnivorous mammals

These mammals eat meat. Their teeth and nails are very strong and sharp which help them to tear up their prey. Common examples are lion, cheetah, wolf, dog, cat and bear etc.

Carnivore mammals that live in sea and eat fish. Their limbs are like oars, which help them to swim and catch the fish. Common examples are walrus, sea lion and seal.

(viii) Fish like mammals

They are totally marine and are biggest animals in water. They look like fish. Their arms and legs are reduced to form structures like oars which help them to swim in water. Their examples are whale and dolphin etc.

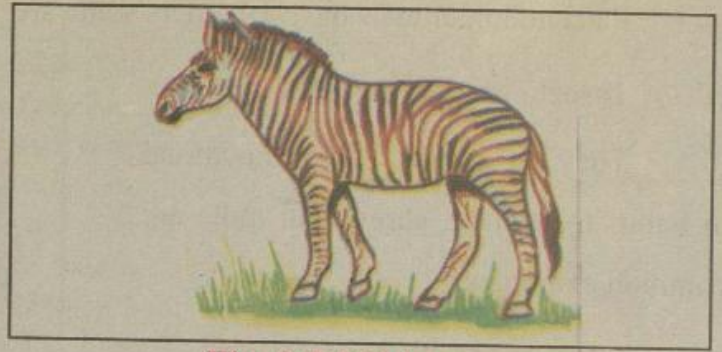


Fig. 9.5.9 Zebra



Fig. 9.5.10 Elephant



Fig. 9.5.11 Lion



Fig. 9.5.12 Walrus



Fig. 9.5.13 Dolphin

(ix) Most intelligent mammals

Their brain is highly well developed and has higher intellect than other animals. Their examples are human, monkey, gorilla and chimpanzee etc.



Fig. 9.5.14 Chimpanzee

Flora and Fauna of Pakistan

Flora

Different types of plants present in a particular region constitute its flora. Hilly regions have snow fall and low temperature. These region have thick forests where trees of Juniper (Sanobar), cedar, chir, chalghozah, olive apple, plum peach and loquat are very common. Plain areas have fertile and less fertile areas. In areas where rainfall is low, desert environment is present in which *Acacia* (Baboal), kikar, ber, pilas etc. grow. Fertile plains have trees of shecsham, bakain, cane, bamboo, and eucalyptus. These are source of timber whereas, fruit trees include mango, banana, kino, orange, grapes jamman etc. Plain and hilly areas have natural meadows that provide fodder for cattles. In sea, rivers, ponds, canals and streams, algae are abundant, which on one hand are the source of food for aquatic animals and on the other hand they provide oxygen to atmosphere.

A large number of plants are used as ornamental plants like rose, motia, jasmine, lady of night, chrysanthemum etc.

Wheat maize, rice, oats, barley, grams, garlic, onion, potatoes, carrots, cabbage and turnips etc. are cultivated in plains and hilly areas to meet our food requirements.

Fauna

Different kinds of animals present in a particular region are known as its fauna. Fauna of different regions can vary as is the case with their flora. In the seas adjoining our coastal areas numerous types of animals are found starting from protozoa to mammals. The most noticeable are octopus, mussels, star fish, sea urchins, crabs, prawns, fishes, amphibians, wheel, dolphin, etc. Many animals are used as food e.g., prawns, crabs and fish etc.

Our rivers are rich in fish life particularly rohu, khagga, malli, trout and silver, grass carps are abundant and used as human food, as well as a source of earning lively hood. In addition to fish, frogs, tortoises, turtle, snakes, crocodiles are also found.

On plains of Pakistan we have very rich wild life. There is a great diversity of land fauna stating from earthworms, almost all kinds of insects, spiders, myriapods, snails, slugs to toads, lizards, snakes and enormous variety of birds and mammals. Some of the birds peculiar to Pakistan are Houbara bustard, partridge, pheasant, falcons, etc. The mammals peculiar to Pakistan include Black buck, Blue bull, Brown bear, Musk deer, Urial, Ibex, Asiatic ass, etc.

Many animals provide milk, meat, hide and wool while some are used for transportation. Some of the animals are now endangered species because of their excessive hunting and pollution.

KEY POINTS

1. Chordates have three diagnostic characters in their larvae or adult
2. Vertebral column is present in Vertebrates.
3. Vertebrates are divided into five Classes.
4. This classification is based on similarities and differences in their characters.
5. Fishes can only live in water.
6. Amphibian can live both on land and in water.
7. Reptiles have tough skin.
8. Fishes, amphibian and reptiles are cold blooded animals.
9. Bird's body is covered with feathers and their fore limbs are modified into Wings.
10. Mammal's body is covered with hairs.
11. Mammals can be divided into three Main groups.
12. Birds and mammals are warm blooded animals because they can maintain their body temperature.
13. Flora and fauna of Pakistan has a rich variety of plants and animals respectively due to a wide range of climatic conditions.

QUESTIONS

1. Fill in the blanks.

- (i). Fish body is covered with _____.
- (ii). Amphibian body is covered with _____ skin.
- (iii). All the reptiles lay eggs in _____.
- (iv). Running birds have _____ muscles
lays powerful.
- (v). Body temperature of a mammal remain _____.

2. Identify the true/false statement.

Also correct the false statement.

- (i). Fishes respire through lungs.
- (ii). Amphibian lay eggs on land.
- (iii). Reptilian skin is dry, coarse and covered with scales.
- (iv). Birds change their body temperature with their environment.
- (v). Mammals digits are provided with nails.

3. Each question is provided with four options, encircle the correct one.

- (i). Which animal has nictitating membrane.
- (a). Chimpanzee (b). Snake

- (c). Frog (d). Kiwi
- (ii). Which animal has powerful pectoral muscles.
- (a). Lizard (b). Fishes
- (c). Pigeon (d). Elephant
- (iii). Which animal can't maintain their body temperature.
- (a). Fishes (b). Lion
- (c). Pigeon (d). Dolphin
- (iv). How many cranial nerves are present in mammals.
- (a). Eight (b). Thirteen
- (c). Six (d). Twelve
- (v). Which mammal lays eggs.
- (a). Whale (b). Squirrel
- (c). Duck bill (d). Rabbit

4. Give short answers to the following questions.

- (i). What is the function of air bladder in fishes.
- (ii). Define hibernation.
- (iii). What is meant by cold blooded animals.
- (iv). Name any four warm blooded animals.
- (v). Enlist three main groups of mammals.

5. (i). Define the characteristics of class

pisces .

(ii). Write a note on toad.

6. (i). Write characteristics of class reptilia.

(ii). Write briefly about a snake.

7. (i). Which animals are included in class aves, what are their diagnostic features?

(ii). In how many groups birds can be divided. Describe any one group with examples.

8. Define characteristics of mammals, how many groups they can be divided.

9. What is meant by placental mammals explain each group in detail.

10. Define marsupial mammals and their characteristics.

Section
4

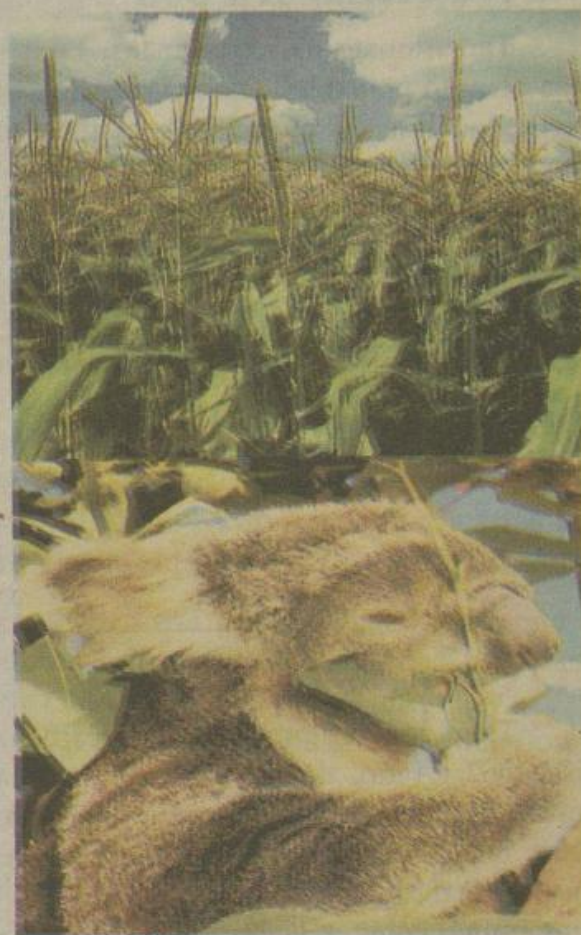
(Maintenance of Life)



FOOD AND NUTRITION

In this chapter you will learn:

- Importance of food and food nutrients.
- Difference between autotrophic and heterotrophic nutrition.
- Autotrophic nutrition
- Factors and conditions necessary for photosynthesis
- Mineral requirements in plants and its importance
- Special modes of nutrition in plants and animals.
- Human nutrition, its components and sources.
- Food technology and problems related to health.
- Balanced diet and its importance with reference to age, sex and job.
- Digestive system and the process of digestion.
- Some disorders of the digestive system.



Need for Food

Living organisms require energy to carry out their diverse activities of life. They maintain the complex structure of cells, reproduce for continuation of their race and face the hazards of environment. They grow in size during their life span as they are small when born and are large when adult. A considerable amount of energy is required to carry out these essential activities of life. The organisms, therefore, need to have some source of energy in order to maintain their life.

All types of work whether physical or biological require energy for their execution. The type of energy required depends on the type of machine involved. If it is an electric machine it requires electricity, a steam engine requires steam and a petrol machine needs petrol for its working. Organisms get their energy from food. The type of food depends upon the kind of organism using

the food. Some organism use inorganic compounds to meet their energy requirements, and some use vegetables (plants) while some others require flesh (animals) as their food. This matter will be discussed later on.

As you know combustion is an essential phenomenon, in running a machine, in which different types of fuels are burnt up to provide energy. In a similar manner organisms burn up their food (metabolize) to get a special form of energy called ATP (Adenosine triphosphate) which is used by them to carry out their activities.

10.1 Nutrients of Food

The ultimate source of energy on the earth is the solar energy. The solar energy is trapped by green plant to prepare their food, which is stored in them, mainly in the form of carbohydrates. This stored food is used by animals as their food. Thus substances acquired by organisms to obtain energy are called **nutrients** and the process by which they are obtained is called **nutrition**. The food of all organisms which depends upon already prepared food has been found to consist of six basic components, shown in the table 10.1. Let us study them one by one.

Table 10.1

There are six basic components of food :

1. Carbohydrates
2. Proteins
3. Fats, Oils
4. Vitamins
5. Minerals
6. Water

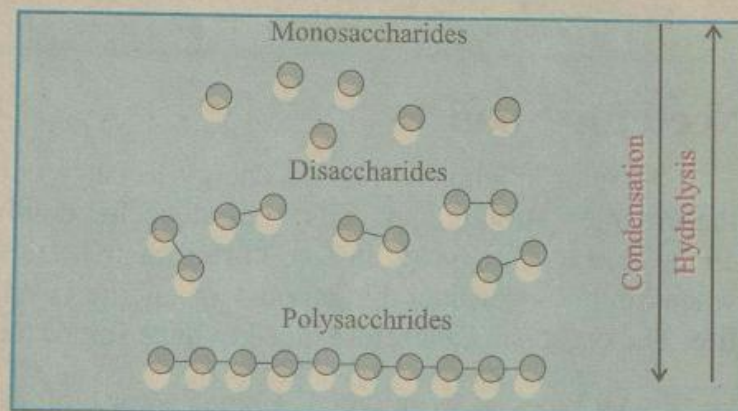
10.1.1 Carbohydrates

They contain three elements carbon, hydrogen and oxygen in which hydrogen and oxygen exists in 2:1 ratio, that is why they are called hydrates of carbon or carbohydrates. One of the simplest carbohydrates is glucose which is a type of sugar. Its chemical formula is $C_6H_{12}O_6$. Glucose occurs in all living things. It dissolves very easily in water and is present in our cells and is transported through circulation of blood to all parts of body. It is the main substance from which living things obtain energy. One gram of carbohydrates provides 3800 calories of energy. Carbohydrates occur in three forms

- a. Monosaccharides
- b. Disaccharides
- c. Polysaccharides.

Monosaccharides are simple sugars ($C_6H_{12}O_6$). Five carbon sugars are also found in living beings ($C_5H_{10}O_5$). Disaccharides are formed by condensation of two

monosaccharide units e.g. sucrose is formed by the combination of glucose and fructose. Maltose is another disaccharide ($C_{12}H_{22}O_{11}$). When many monosaccharides link together they form polysaccharides. A single polysaccharide may have many hundred units of monosaccharides.



Glycogen and starch are examples of polysaccharides. Glycogen occurs in animals and starch in plants. Another polysaccharide is cellulose present in the cell walls of plants. It is the most abundantly occurring carbohydrate. The general formula of a polysaccharide is $(C_6H_{10}O_5)_n$.

10.1.2 Proteins

Proteins contain carbon, hydrogen, oxygen and nitrogen and sometimes some amount of sulphur. A protein molecule is composed of many building blocks linked together to form a chain. Amino acids are the building blocks of a protein molecule. About twenty different amino acids, occur in nature, that combine in different manners to make different kinds of protein. Some proteins are fibrous. They form different structures in the body like muscles, bones and skin. They also occur in our blood and cells. The enzymes which control different chemical reactions in the body are also protein in nature. As a result of protein catabolism, energy is released. One gram of protein produces 4.3 kilo cal of energy which is used to synthesize ATP (Adenosine tri-phosphate) molecules, (Fig 10.1).

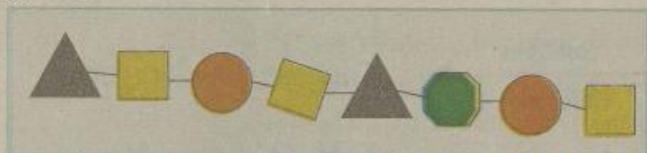


Fig 10.1 A chain of amino acid which form a part of protein molecule. Amino acids

10.1.3 Fats and Oils

They are very important compounds made up of carbon, hydrogen and oxygen. Fats contain more carbon and hydrogen as compared to oxygen. A fat molecule has two parts, glycerol and fatty acids. Different kinds of fats contain different fatty acids which may be saturated or unsaturated.

Unsaturated fatty acids (molecules with one or more than one double bonds) are liquids at room temperature and are called oils. These are good for human health. Saturated fatty acids (molecules without double bonds) are solid at room temperature and are called fat. They are not good for human health because they increase cholesterol level in the body thus affecting the flow of blood in the vessels.

Vegetable fats are liquid and are called oils, e.g. mustard oil, olive oil, coconut oil, corn oil etc. Animal fats are solid, for example butter, ghee and fatty meat.

Fats and oils are a rich source of energy. They provide double energy as compared to carbohydrates and proteins. One gram of fat on oxidation releases 9.1 kilo cal. of energy to make ATP.

Now that you have come to know that complex compounds like carbohydrates, proteins, fats, vitamins, minerals and water make up the food of living organisms. Let us now study how organisms acquire this food.

There are two methods of acquiring food:

1. Autotrophic nutrition
2. Heterotrophic nutrition

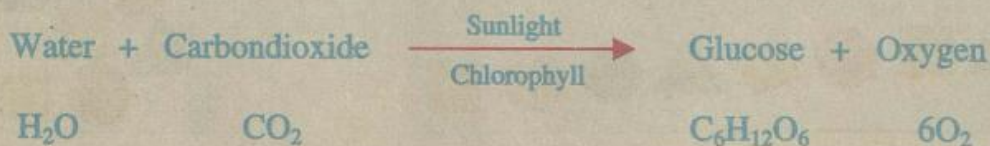
10.2 Autotrophy

Green plants have autotrophic nutrition in which they use solar energy with the help of chlorophyll to combine carbon dioxide and water for making glucose. This process of glucose synthesis is called **photosynthesis**.

Heterotrophs referred to as animals, are unable to make their own food. They use vegetables and flesh of other animals as their food. The vegetables or flesh have carbohydrates, proteins and fats in addition to some minerals, vitamins and water.

10.2.1 Photosynthesis

Photosynthesis is a Latin word derived from two words **photo** (light) **synthesis** (building up). During photosynthesis green plants build up carbohydrates from carbon dioxide and water. The energy needed for this process is obtained from sunlight, which is absorbed by chlorophyll and oxygen is given out as a by-product. Leaves are the major sites of photosynthesis in most plants but all green parts of a plant including green stems; un-ripened fruit can carry out photosynthesis. Temperature also plays a very important role in photosynthesis as it affects the rate of photosynthesis. The process takes place during day time only and can be represented by a chemical equation.



The organic compound formed as a result of photosynthesis is glucose as shown by the above chemical equation, other complex organic compounds are later formed from glucose, e.g. complex carbohydrates, protein, fats and vitamins. These compounds are of extreme importance to the plants for growth and development. Plants also need some minerals in minute quantities as well. All these compounds help to make cell wall, cell membrane, protoplasm and enzymes etc.

Condition and factors necessary for Photosynthesis

A few conditions cited below are necessary for this process, without which the process would not take place. These conditions act as factors which affect the rate of the process.

1. Water

Plants need water for many other activities besides photosynthesis and if they do not get enough water they will not photosynthesize quickly. It enters the root hair from the soil and after passing through various cells reaches the xylem of the root. From here it moves to the stem and then the veins of the leaves. Finally, it reaches the mesophyll cells in the leaves. It provides hydrogen for the synthesis of glucose and helps in opening and closing of stomata. If leaves get less water, less stomata open, which retards the rate of photosynthesis. Opening of more stomata provide more CO_2 for photosynthesis.

2. Carbon dioxide

The amount of carbon dioxide in the atmosphere is about 0.03% and does not vary much. Its amount differs from place to place which may affect the rate of photosynthesis, for example, the concentration of carbon dioxide close to the ground in a dense forest is higher than in an open field. Why is it so? Although carbon dioxide is needed in very little quantity by the plants, yet photosynthesis can not take place without it. It diffuses from the air into the intercellular spaces through stomata and enters the chloroplasts in the mesophyll cells. Carbon dioxide provides carbon to the newly synthesized glucose molecule. If the amount of carbon dioxide in the atmosphere

increases to 1 %, rate of photosynthesis also increases, and it starts decreasing if concentration of carbon dioxide is decreased. If the concentration of carbon dioxide decreases below 0.03%, the rate of photosynthesis also declines.

3. Chlorophyll

Chlorophyll is the green substance found in organelles called chloroplasts, which are found in the green leaves and herbaceous stems. In leaves it is present in the mesophyll cells. Chlorophyll converts light energy to chemical energy and makes food in plants. Plants lacking chlorophyll can not carry out photosynthesis.

1. Can photosynthesis take place in the presence of a lighted bulb?
2. Why are mesophyll cells so named?
3. How do aquatic plants obtain carbon dioxide?

4. Sun light

Light is very important for photosynthesis, without which the process cannot take place. It provides energy needed for the synthesis of glucose molecule. Light intensity varies from day to day and from place to place. Plants photosynthesize faster on a bright sunny day than on a cloudy day. White light is composed of seven colours. The two colours which are best for photosynthesis are blue and red. If a plant is deprived of these wavelengths of light, the plant cannot photosynthesize properly and does not make much starch.

The intensity of light also affects the process. Photosynthesis can take place even in low light but very bright sunlight actually slows down the process, as it contains a lot of ultra violet radiations which damage plant cells.

5. Temperature

A suitable temperature is essential for photosynthesis to take place at a normal rate. The temperature varies from place to place and at different times of the day and year. If the temperature rises gradually upto 40°C, the rate of photosynthesis also increases. However, if the temperature rises still further, photosynthesis slows down and may stop altogether, because heat destroys the enzymes needed for chemical reactions. Have you observed plants flourishing better in a green house. Why?

Leaf adaptation to Photosynthesis

You have already studied the external and internal structure of *Brassica* leaf in the previous chapter. If you recall the structure of the leaf you may realize that leaves are the most appropriate structures for photosynthesis. They are often referred as food factories of nature. (Fig. 10.2).

Leaves have different shapes and sizes but they are generally flat. Therefore, they have a large surface area which helps them absorb large quantity of carbon dioxide from the air and light energy from the sun.

You have noticed that leaves are arranged on the stem and branches in such a manner that they receive maximum sunlight to carry out photosynthesis. They fit together so closely that very little light passes through them to the ground below. This is why it is shady under many shrubs and trees. Stomata are more numerous on the under side of the leaf. They allow exchange of gases. Stomata open during day time when there is light and photosynthesis is taking place and they close at night when it is dark and photosynthesis stops.

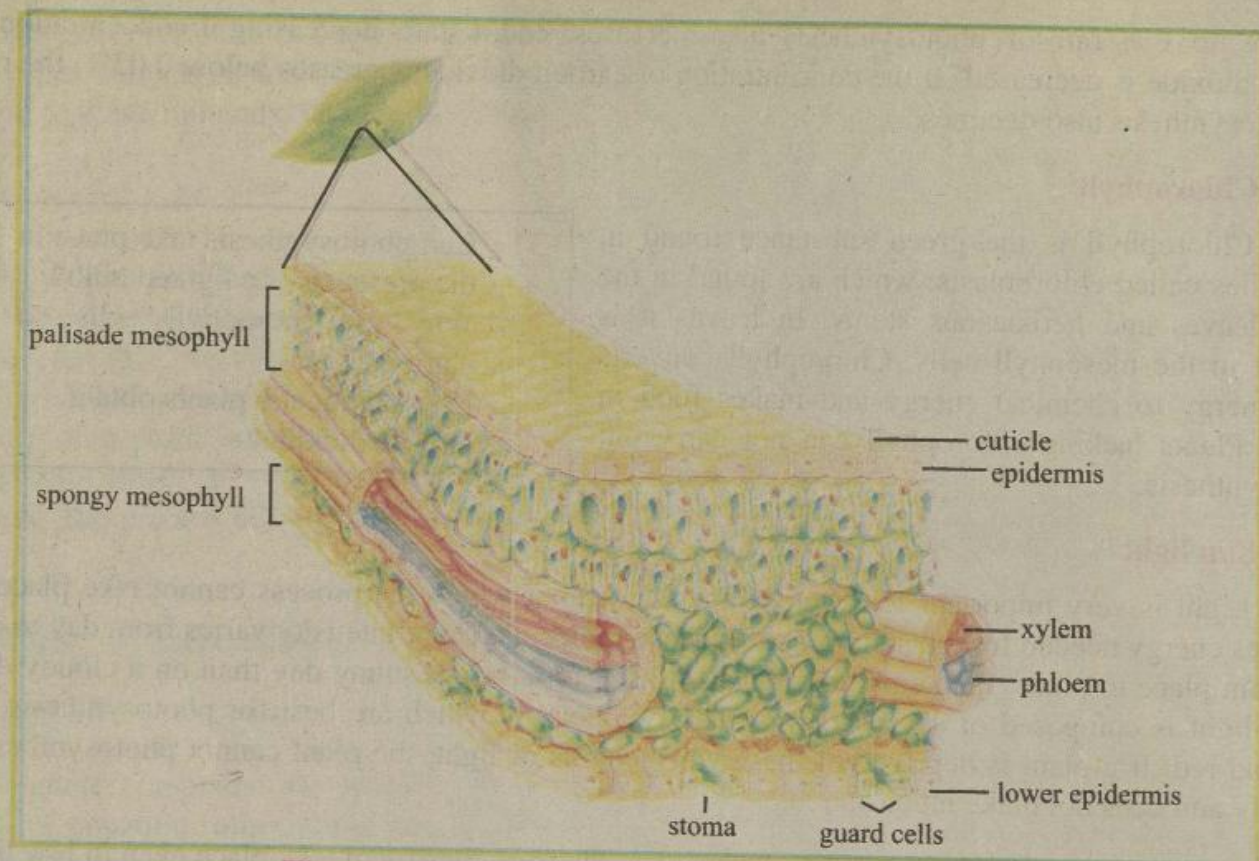


Fig. 10.2 External and internal structure of a leaf

Leaves are thin and less than a millimeter thick. This reduces the distance for carbon dioxide to diffuse after it has entered the leaf. The lamina of the leaf is supported by veins to keep it expanded which makes them suitable for photosynthesis. The leaf lamina is lined by a layer of epidermis on the upper and lower sides. The cells of this layer are very closely packed with no intercellular spaces. In some plant a layer of cuticle is present outside the epidermal layer, which reduces the rate of transpiration and also helps to converge maximum light on the lower side of the leaf.

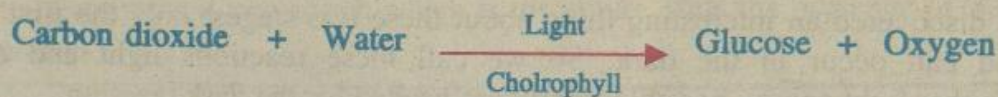
If you observe the colour of the leaf you will notice that leaves are mostly green due to a substance called chlorophyll, found in special bodies called chloroplasts. Studies reveal that mesophyll cells are rich in chloroplasts. Why?

The palisade and spongy mesophyll cells contain chloroplasts. The palisade cells are packed closely without spaces and are near the surface of leaf on the side which receives the maximum light. They are full of chloroplasts enabling them to carry out maximum photosynthesis.

The spongy mesophyll cells are loosely packed with large intercellular spaces. Carbon dioxide enters through stomata and diffuses into the spaces of the moist cell walls finally reaching the mesophyll cells. Thus leaves are the best suitable structure for photosynthesis to take place.

Leaves have other pigments besides chlorophyll e.g. orange pigment called carotene and yellow pigment called xanthophyll. Similarly there are other plastids also besides chloroplasts for example chromoplasts which give colour to the petals and leucoplast found in the storage organs, e.g. potatoes.

Light and Dark reactions



If you look at the above chemical equation showing the process of photosynthesis, you may consider it as a simple process. In reality it is not as simple as it looks. During this process a number of reactions occur and the process is completed in two stages: Light reactions and dark reactions. (Fig. 10.3).

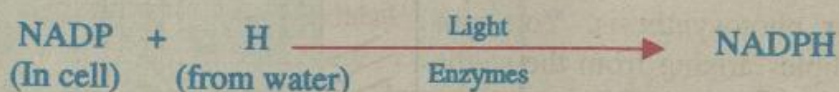
Light reactions

When light falls on the leaves, it is absorbed by chlorophyll. The solar energy is utilized to split water into oxygen and hydrogen this is called **photolysis**, (photo means light and lysis: to break), and oxygen is released during this process. As this process takes place only in the presence of light, it is called light reaction.

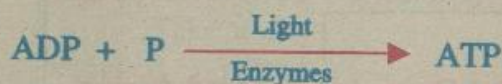
During light reaction two compounds are formed when the solar energy is converted into chemical energy, these are:

1. **NADPH** (Nicotinamide Adenine Dinucleotide Phosphate).
2. **ATP** (Adenosine Tri-Phosphate)

NADP, already exists in the cells of the leaf. The hydrogen released on the splitting of water molecule is accepted by this compound and it become reduced to form NADPH.



The compound ADP (Adenosine Di-Phosphate) is already present in the cell combines with the phosphate group using light energy to form a compound called ATP (Adenosine Tri-phosphate)



These compounds are energy rich compounds which are needed for the dark reactions of the process.

Dark reactions

Utilizing the energy from ATP and the hydrogen from NADPH, water combines with carbon dioxide to form carbohydrate. Thus the solar energy is now converted into chemical energy to form glucose. Other organic compounds are further synthesized from this glucose.

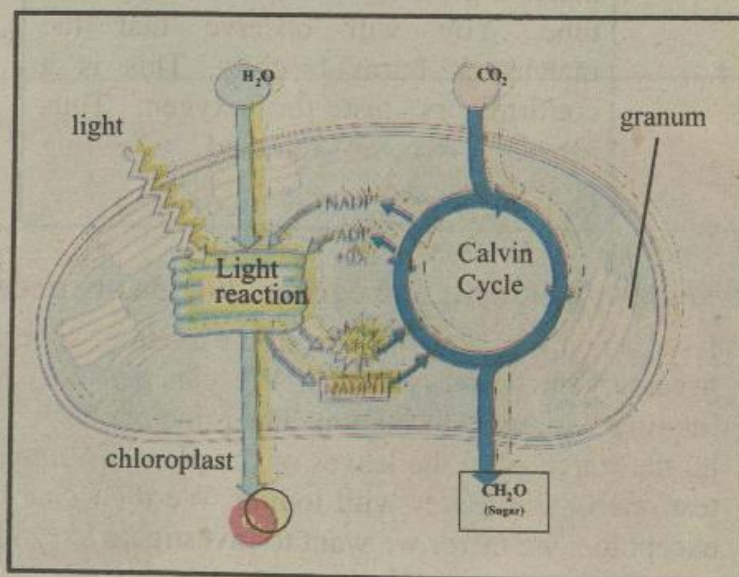


Fig. 10.3 Light and dark reaction

This stage is also completed in a series of chemical reactions with the help of enzymes. Scientists have discovered an interesting thing about these two stages: only the first requires light, and the second can occur in the dark. So we call these reactions light and dark reactions respectively. Neither light energy nor chlorophyll are needed for the dark reaction.

Various steps of the dark reactions were studied by a scientist named Melvin Calvin, thus it is also called as **Calvin's Cycle**. When scientists performed experiments with chlorella plant they found that the rate of photosynthesis increased in intermittent light and again if temperature is raised during dark reaction, the rate increases invariably. This also proved that light reactions are photochemical reactions and dark reactions are chemical reactions, not dependent on light.

Practical Work:

Oxygen is released during photosynthesis.

Take a 500 ml beaker half filled with water. Now take a short stemmed funnel and invert it over a few twigs of hydrilla plant. A test tube filled with water is inverted over the funnel stem. The funnel is raised above the bottom of the beaker to allow free water circulation. (Fig. 10.4).

Now place the apparatus in sunlight for photosynthesis. You will observe bubbles arising from the stems of hydrilla plant, and collecting in the test tube. When sufficient gas has collected, remove the test tube and insert a glowing matchstick in the test tube. You will observe that the matchstick burns brightly. This is a confirmatory test for oxygen. Thus oxygen is released during photosynthesis.

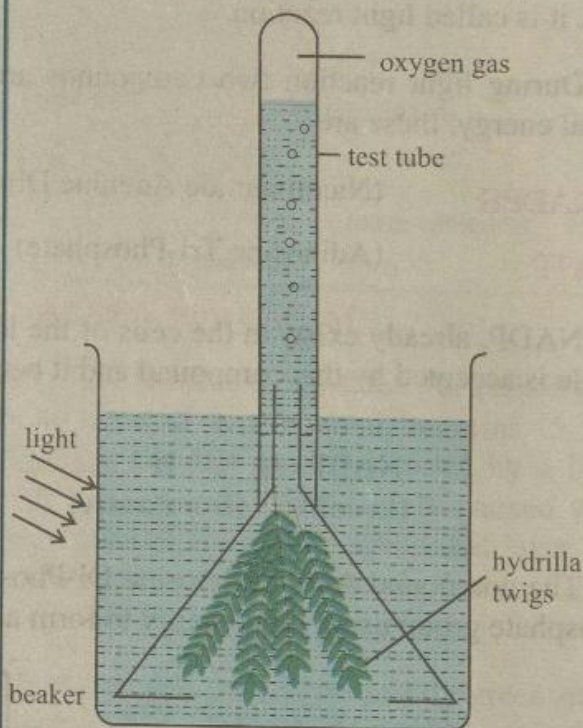


Fig. 10.4 Oxygen is released during photosynthesis

Chlorophyll, light and carbon dioxide are necessary for Photosynthesis

You now know that carbon dioxide, water, chlorophyll, light and suitable temperature are necessary for photosynthesis. We can perform experiments to find out if these four factors are required for starch formation. The principle behind the experiments is quite simple. First we remove all the starch from the leaves of the plant. To make sure that it has been completely de-starched we test one of the leaves with iodine. We then give the plant every thing it needs for photosynthesis except the one factor we want to investigate like chlorophyll light, carbon dioxide or water.

As in other biological experiments we must have a control with which to compare the result. The control plant is given every thing it needs, including the factor, which we are investigating.

The glucose formed as a product of photosynthesis is readily soluble in water; the plant immediately converts it into starch which is insoluble. Thus the presence of starch is an evidence of photosynthesis.

Practical Work:

Testing a leaf for starch.

1. A potted plant is de-starched by leaving it in a dark cupboard for two or three days. A leaf is detached from the de-starched plant and dipped in boiling water for half a minute to kill the protoplasm. (Fig. 10.5).
2. The leaf is boiled in methylated spirit using a water bath. You will notice that all the chlorophyll comes out, leaving the leaf colourless.
3. Alcohol has made the leaf brittle, now dip it in boiling water to make it soft. Now spread it on an even surface or in a dish.
4. Put a few drops of iodine solution on the leaf. You will observe that any parts which turn blue indicate the presence of starch. If there is no starch, then the leaf turns brown (iodine turns starch blue).

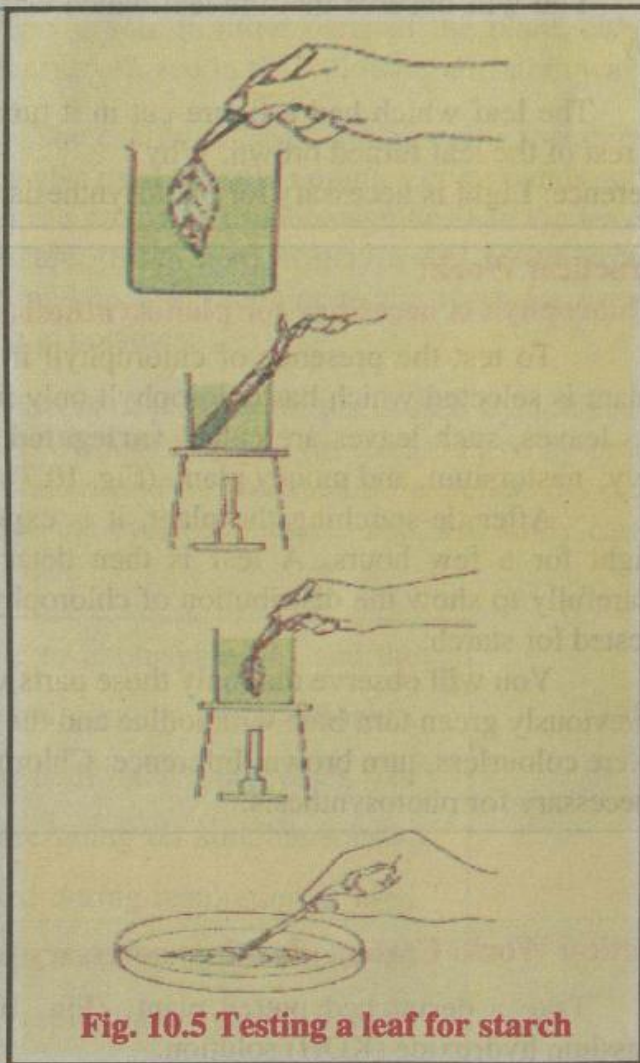


Fig. 10.5 Testing a leaf for starch

Practical Work:

Light is necessary for photosynthesis.

Take a de-starched potted plant. Select any two leaves, but do not detach them from the plant. Cover one of the leaves completely with a thick black paper, so that no light can enter the leaf. Cover the second leaf with a black paper,



Fig. 10.6 Light is necessary for photosynthesis

which has any figure cut in it. After 4 to 6 hours of day light, the leaves are detached and tested for starch.

You will observe that the leaf which was completely covered with black paper turns brown. Why?

The leaf which had a figure cut in it turned blue only in the area of the cut figure, whereas the rest of the leaf turned brown. Why?

Inference: Light is necessary for photosynthesis. (Fig. 10.6).

Practical Work:

Chlorophyll is necessary for photosynthesis

To test the presence of chlorophyll in the cells, a plant is selected which has chlorophyll only in patches in its leaves, such leaves are called **variegated leaves**, e.g. Ivy, nasturtium, and money plant. (Fig. 10.7).

After de-starching the plant, it is exposed to day light for a few hours. A leaf is then detached, drawn carefully to show the distribution of chlorophyll and then tested for starch.

You will observe that only those parts which were previously green turn blue with iodine and the parts that were colourless, turn brown. Inference: Chlorophyll is necessary for photosynthesis.



Fig.10.7. Chlorophyll is necessary for photosynthesis

Practical Work: Carbon dioxide is necessary for photosynthesis.

Take a destarched potted plant (Fig. 10.8). Now take a wide mouthed bottle with some potassium hydroxide (KOH) solution.

Fit a cork cut lengthwise on the mouth of the bottle. Now select any leaf from the plant (without detaching) and pass the leaf through the cut section of the cork, in such a way, that half of the leaf is inside the flask and half of it remains out of the flask. Now place the complete apparatus in sunlight for a few hours, so that photosynthesis can take place. Pluck the leaf from the plant and test for the presence or absence of starch. The part of the leaf which was inside the bottle was deprived of CO_2 and thus was unable to carry out photosynthesis and hence turned brown. The part which was out side the bottle, received carbon dioxide and was able to carry out photosynthesis, hence turned blue.

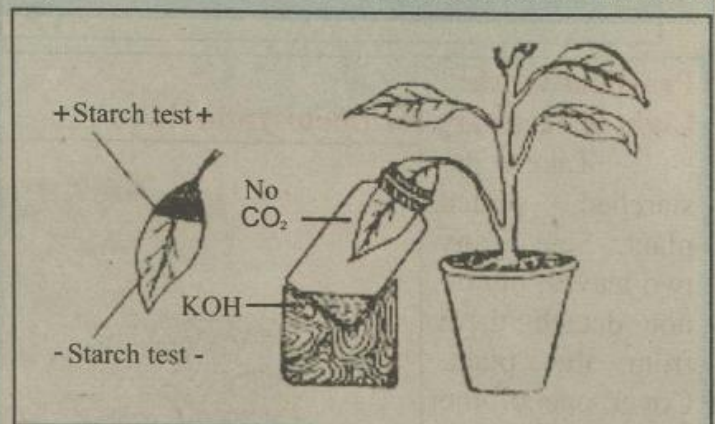


Fig. 10.8 Carbon dioxide is necessary for photosynthesis

Inference: Carbon dioxide is necessary for photosynthesis.

Most life forms are dependent on Photosynthesis

The glucose (plant sugar) produced as a result of photosynthesis is utilized by plants in different ways. Some of the sugar formed is broken down to obtain energy for the leaf. Some is converted into starch and stored, the rest of the sugar is sent to other parts of the plant, either to supply energy there or to be stored. The glucose is further utilized in the following different way:-

It is used to make cellulose for the cell walls. The energy released during cellular respiration is used to perform different functions. The glucose is also used to build complex compounds such as proteins, fats and other organic compounds. The glucose produced by photosynthesis in the leaves is carried by the phloem out of the leaf and into the stem. From here, it may travel to the growing regions, to fruits e.g. grapes, mangoes, apples and melons and seeds or to the roots for example radish, carrot and turnips, or to other storage organs e.g. potatoes.

The food prepared by the plants during the process of photosynthesis is used by animals and human beings as food, thus the importance of plants is evident. Oxygen gas released as a by-product during photosynthesis is used by animals for respiration and carbon dioxide expelled out during respiration is used by plants in photosynthesis. Thus the cycle continues. You will study carbon-hydrogen-oxygen cycle in the coming chapters.

Respiration is a process opposite to photosynthesis, and the respiring plants take in oxygen and give out carbon dioxide. In plants, during daytime both the processes of photosynthesis and respiration are going on simultaneously, therefore, carbon dioxide released during respiration is used to make food by photosynthesis and the oxygen released during photosynthesis is used in respiration by plants. Rate of photosynthesis is higher during daytime as compared to respiration and it stops at night, whereas respiration continues during day and night. You are often advised not to sleep under the plants. Why?

10.2.2 Mineral requirements in plants

Roots absorb water from the soil. This is not simple pure water. In reality it contains many minerals dissolved in it. Different plants absorb different minerals in different quantities. Elements required by plants in relatively large amounts are called **macro-nutrients**. There are nine macronutrients including the six major ingredients of organic compounds viz., carbon, oxygen, hydrogen, nitrogen, sulphur and phosphorus. The other three macro-nutrients are potassium, calcium and magnesium.

Elements that plants need in very small amounts or in traces are called **micro-nutrients**. They are eight in number and are iron, chlorine, copper, manganese, zinc, molybdenum, boron and nickel. Table 10.2 shows the elements, their form of existence in the soil and their role in plants.

Table 10.2 Mineral requirements of plants

Name of Element	Forms in which absorbed	Function in plants
Macro-nutrients		
Carbon	CO_2	Basic component of organic compounds in plants used in respiration and photosynthesis.
Oxygen	O_2	Used in respiration
Hydrogen	H_2O	Used in reduction (in photosynthesis)
Nitrogen	NO_3 , NH_4	In nucleic acids, proteins hormones, co-enzymes
Sulphur	SO_4^{2-}	Component of proteins and co-enzymes
Phosphorus	H_2PO_4^- , HPO_4^{2-}	Nucleic acids, phospholipids, ATP and part of co-enzymes
Potassium	K^+	Synthesis of proteins, regulate the balance of water and opening of stomata
Calcium	Ca^{2+}	Making of cell wall, speeds up many enzymes
Magnesium	Mg^{2+}	Part of chlorophyll, speeds up many enzymes
Micronutrients		
Chlorine	Cl^-	Splitting up of water molecule, keep the balance of water
Iron	Fe^{3+} , Fe^{2+}	Activate enzymes
Boron	H_2BO_3^-	Chlorophyll synthesis, transport of carbohydrates and synthesis of nucleic acids
Manganese	Mn^{2+}	Building amino acids, activate enzymes, splitting of water molecule
Zinc	Zn^{2+}	Synthesis of chlorophyll and activates enzymes
Copper	Cu^+ , Cu^{2+}	A component of many enzymes
Molybdenum	MoO_4^{2-}	In the fixation of nitrogen
Nickel	Ni^{2+}	In the metabolism of nitrogen

Importance of chemical fertilizers in Agriculture

If you observe a natural ecosystem you will find that microorganisms present in the soil decompose the dead organic matter. The mineral ions set free are added to the soil thus enriching it. In man's agricultural ecosystems organic matter with minerals is removed by frequent crops grown year after year. The chemicals are not returned to the soil and the soil thus becomes poor, deprived of both humus and minerals which are essential for healthy plant growth and high yield of crops. Therefore, farmers add fertilizers to the soil to maintain fertility of the soil. These fertilizers may be organic, inorganic or both in nature.

The decaying animals refuse and excreta along with the rotten leaves, fruits and vegetables form a very useful humus. This humus when added to the soil can add to its fertility i.e. it enriches the soil with organic matter and minerals. The humus not only makes the soil fertile but it also prevents the washing away of the top fertile soil by rains. It also reduces the danger of destroying 'crumb' structure of fertile soil.

Inorganic fertilizers help to replace the mineral ions lost by successive production of crops. The usual three elements added to the soil in the inorganic form are nitrogen, phosphorus and potassium, since these are the ones, which are mostly depleted by the growing crops continuously.

Nitrogen is usually added to the soil in the form of ammonium nitrate or ammonium sulphate. Phosphorus and potassium are added in the form of super phosphate, potassium chloride respectively.

In discriminate use of inorganic fertilizers can disturb the balance of mineral ions in the soil. This continuous use for a long time can cause the wash away of top fertile soil. Moreover, these are very expensive, hence the inorganic fertilizer should only be used under the proper advice of expert.

Hazards of using chemical fertilizers

Continuous and excessive use of chemical fertilizers leads to a loss of organic humus, a deterioration of the fertility of top soil and a decrease in the porosity. Consequently, the roots do not get oxygen and cannot absorb the salts effectively. The unabsorbed nitrates are carried by rain water into rivers and lakes, where they accumulate and pose a threat to aquatic life. The top fertile soil gets destroyed thus exposing the soil to become dry and powdery which may be blown away by winds. Those barren lands can be ultimately converted into deserts.

The excessive nitrates in the soil can raise the level of free nitrates in the food plants causing dangerous to people using them.

These problems can be reduced to some extent if such chemical fertilizers are used which are less soluble and release their nitrogen slowly into the soil, likewise the use of organic manure should be increased so that the amount of humus can be stored to keep the soil structure intact.

10.2.3 Special modes of nutrition in plants

Heterotrophic nutrition

As you know green plants are autotrophic as they can synthesize their own food through photosynthesis. There are number of plants, mostly non-green, which have acquired other modes of nutrition. These modes are as follows:-

1. Parasitic
2. Saprophytic
3. Insectivorous
4. Symbiosis

1. Parasitic Plants

These plants are unable to prepare food by the process of photosynthesis and depend for their food requirements on other living plants. The plant from which they derive their food is called the **host**. Parasitic plants have special roots called **haustoria** which penetrate into the vascular bundles of the host plant and draw food material for themselves. Thus the host plant grows weaker and gradually dies. Cuscuta (dodder plant) is an example of parasitic plants (Fig. 10.9).



Fig. 10.9 Cuscuta

2. Saprophytic plants

These plants are devoid of chlorophyll and are unable to prepare their food at all. They draw their nourishment from the decomposed matter of the dead remains of animals and plants. Examples of some saprophytic plants are Neottia and Monotropa.

3. Insectivorous Plants

These plants have chlorophyll in their leaves and can prepare their food by the process of photosynthesis (Fig. 10.10). These plants grow in places, which are deficient in nitrogen and sulphur such as marshy areas. This deficiency affects the growth and development of these plants. Their nutritional needs of proteins are supplemented by small insects, which are trapped, digested and absorbed by the modified leaf parts.

Small insects are attracted by the peculiar shape, smell and nectar secreted by the plants. Examples of insectivorous plants are pitcher plant, bladder wort and venus fly trap

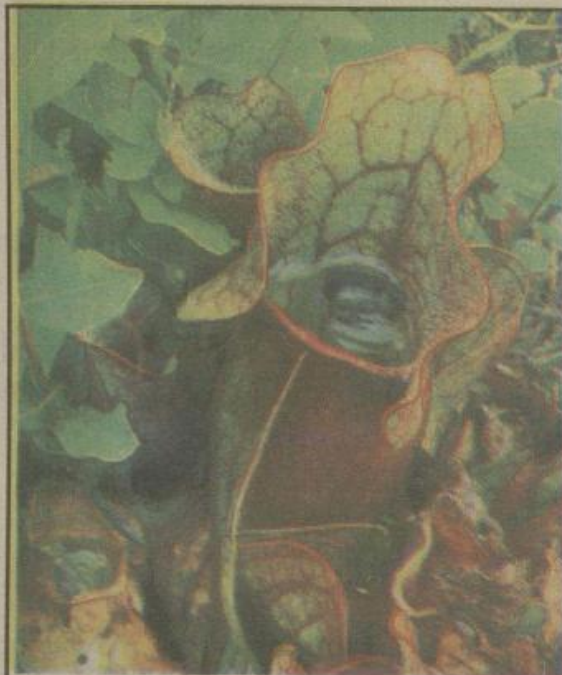


Fig 10.10 Pitcher plant



Venus fly trap

4. Symbiosis

It is a mutually beneficial association existing between two organisms and both organisms derive benefit from each other without causing any harm to each other example, leguminous plants, (grams, peas and beans). These have bacteria in their root nodules which absorb nitrates from the soil, and supply it to the plant and in return obtain nourishment and shelter from the plants. This is called **symbiosis** (mutualism) in which both organisms benefit from each other and the organisms are called **symbionts**.

10.3 Modes of nutrition in animals

Animals do not have chlorophyll and are thus unable to prepare their food from inorganic compounds, therefore, they obtain their food from the organic matter produced by other organisms. This mode of nutrition is called **heterotrophic nutrition**.

All animals are heterotrophs. Among unicellular animals some take in solid particles of food materials in their cells, they are called **holozoic feeders** and the nutrition is termed as **holozoic nutrition**. Where as some absorb liquid organic substances from their environment and use them as food, they are called **saprozoic feeders** and the mode is called **saprozoic nutrition**.

Multicellular animals vary in their mode of nutrition. All the animals which feed on plant material are called **herbivores** for example, cow, buffalo, goat and zebra etc. They have very strong teeth for grinding and crushing the grass and vegetation. All herbivores gulp their food quickly, and store it in their stomach. The partly digested food is brought back into the mouth for further mastication. This is called **regurgitation**.

All flesh-eating animals are called **carnivores** for example, cat, dog, lion, tiger etc. They possess very sharp and pointed teeth and claws. Both claws and teeth help to tear and grasp the prey tightly preventing its escape.

Man, bear and crow ingest food materials from both plant and animal sources and are called **omnivores**. Some animals like a parrot or a squirrel depend on fruit and seeds and are called **frugivores**. Insect eating animals-for example, a frog, a lizard etc are called **insectivores**.

Some animals derive their food from a living host and are called **parasites**. They are of two types.

1. Ecto-parasites
2. Endo-parasites

Ectoparasites obtain their food by living on the body surface of their host, and get nourishments by sucking blood - for example head lice, dog fleas and leeches etc.

Endoparasites live inside the bodies of their hosts and obtain food either from the blood or directly. These are hookworms, tape worms, ascaris, liver fluke and blood-fluke etc.

10.3.1 Nutrition in Man

Like all other animals human beings need food for following activities:-

1. For energy which may be used to carry out different functions in the body.
2. To build new protoplasm in the cells, renew and replace damaged cells and tissues for growth and reproduction.
3. To maintain health and build resistance against diseases.

Man's diet consists of the following components.

- i. **Carbohydrates**
- ii. **Proteins**
- iii. **Lipids**
- iv. **Vitamins**
- v. **Mineral salts**
- vi. **Water**

You have already studied the chemical nature of these compounds and the functions they perform. Here, we shall study the sources obtaining these components. (Fig 10.11).

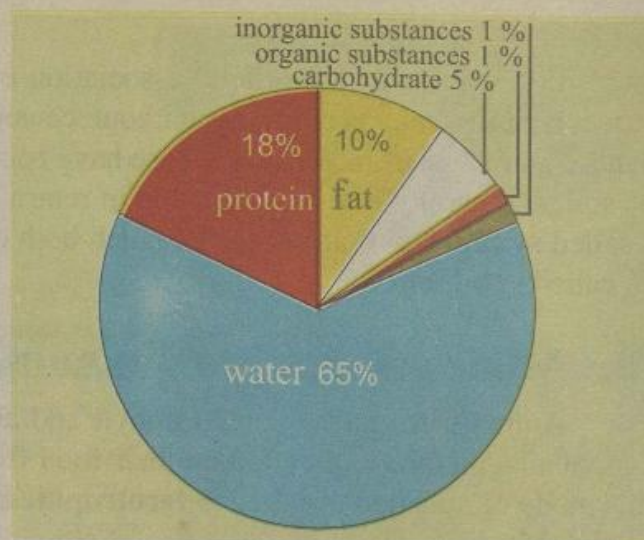


Fig. 10.11 Pie chart

i) Carbohydrates

Carbohydrates containing starch can be obtained from cereals and their products such as wheat, rice, maize, oats, barely. They can also be obtained from carrots, radish, turnip, beet, beet root and potatoes. Simple sugar called **glucose** is obtained from grapes. The sugar derived from fruit is called **fructose**, that from beet and sugar cane is called **sucrose** and that from milk is called **lactose**.

Practical work: Iodine test for starch

1. Take a potato and cut it into two halves. Make a pit in the cut halves with a knife. Now pour a few drops of iodine with the help of a dropper in the pit. You will observe these places turn deep blue or blue black indicating the presence of starch.
 2. Presence of sugar can be tested by Benedict Test.
Take a test tube with 2 ml glucose solution. Now add 2ml Benedict solution to it and shake the mixture thoroughly. Place the test tube gently in a beaker of boiling water for 1 minute. Shake the mixture well so that it gets well heated. A green or yellow/orange colour indicates low concentration of glucose and reddish brown precipitate if indicates high concentration of glucose.
- Name a few substances containing sugar.
 - Name a few substances containing starch.

Carbohydrates are the cheapest and important source of energy. Excess carbohydrates are stored as glycogen in the liver and muscles, or converted to fats and stored in the fat cells beneath the skin and causes obesity.

Children, labourers and people involved in physical labour need more carbohydrates in their daily diet whereas others should avoid them because their excess in the body can cause blood pressure, diabetes, obesity and heart diseases, therefore, carbohydrate products should be taken with care.

ii) Proteins

Proteins can be obtained from both animals and plant sources. Mutton, beef, fish, chicken, milk and cheese are animal sources, whereas, cereals, pulses, beans and dry fruit are plant sources of proteins. Plants can synthesize all the amino acids they need from carbohydrates, nitrates and sulphates but animals can not synthesize all amino acid.

There are about twenty different kinds of amino acids from which different proteins in the human body can be synthesized. There are number of amino acids which a human body can synthesize (from other substances or amino acids) within the body. On the other hand, there are approximately ten amino

acids, which human beings cannot make. These are called **essential amino acids** and can be obtained directly from proteins in the diet. Proteins are essentially required for growth and development. Growing children, pregnant women and lactating mothers need a lot of proteins. An adult requires 50-100 gms of proteins daily. Protein deficiency in children can cause a disease called Kwashiorkor (Fig. 10.12). Proteins play an important role in the building of cellular protoplasm, muscles and connective tissues. They are also required for making enzymes, hormones and antibodies. If proteins are eaten in excess than needed by the body, the excessive amino acids are converted into carbohydrates by the livers, which are either oxidized to release energy or are converted into glycogen and fat and stored. Proteins are never stored in the form of amino acids. In the liver they are broken down and changed into urea and passed out through the excretory system. Thus, their excessive use can be harmful and sometimes may damage our liver and kidneys.

There are thousands of organic compounds in a human body, out of which many amino acids and vitamins and twenty-one mineral salts are obtained from the environment directly, these are called essential nutrients. The rest of the compounds are synthesized within the body if the requisite raw material is available.

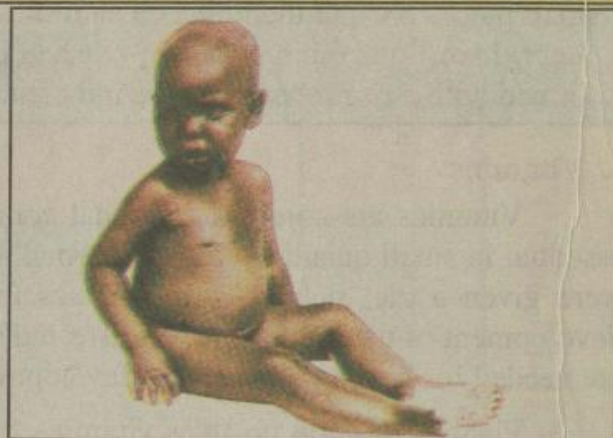


Fig. 10.12 A child suffering from Kwashiorkor

Practical Work:

Biuret test for the presence of proteins

Take 2ml albumen in a test tube. Add 1ml sodium-hydroxide to it. Now add to this mixture, one percent copper sulphate drop by drop and shake it well. What do you observe? A purple colour of the mixture indicates the presence of proteins.

3. Lipids

Lipids are obtained from two sources. Ghee, butter, cream, animal fat and fish oil are obtained from the animal source and oils from mustard, olives, coconut, maize, soyabeans, sunflower and peanuts are obtained from the plant source. The use of fat rich products increases in winters because they provide double the amount of energy as compared to carbohydrates. They provide 9000 cal/gm energy to the body.

In plants fats are stored in seeds, and in animals, they are found beneath the skin and around the kidneys where they are not only stored but also protect these parts. They provide materials for building new protoplasm and cell membranes. Some fatty acids are essential for man.

Saturated fats (animal fats) should be used with great care in our diet as they lead to rise in the cholesterol level, which accumulates in the blood vessels, and thus affects the flow of blood in the arteries. This can result in heart attack. Besides this, obesity, blood pressure and disorders of the kidneys are also caused by excessive use of fats in our diet. Some scientists believe that the more unsaturated fat we eat, the healthier we are likely to be as they do not raise the cholesterol level.

Practical Work: Grease-spot test for lipids

1. Rub fatty material into the center of a clean sheet of paper. Hold the paper to light. A translucent stain appears where the fat was rubbed into the paper.
2. Emulsion test

Take a few drops of coconut oil in a test tube. Add 2ml ethanol to the oil and shake thoroughly until the fat dissolves. Now add 2ml of water to this mixture and observe. A cloudy white emulsion is formed. This is a sure test of fats. Now take a few peanuts, crush them to small pieces and put them in a clean test tube. Take 2ml ethanol in a test tube containing 2ml of water. Invert this mixture on the crushed peanuts and shake it thoroughly. A white emulsion is formed with a rise in temperature indicating the presence of fats in the peanut seeds.

4. Vitamins

Vitamins are complex chemical compounds. Although they have no energy value, they are essential in small quantities for the normal activities of life. It has been observed that when animals were given a diet rich in carbohydrates, fats and proteins but lacking vitamins, the growth and development of the organisms was affected and the animal suffered from various diseases. Vitamins are needed for healthy growth and development of the body.

Plants can build up their vitamins from simple substances but animals obtain it directly or indirectly from plants. Fifteen or more vitamins have been isolated and most of them seem to act as essential part of coenzyme involved in chemical changes taking place in the body. They also influence vital processes going on in the body.

If our diet has variety and consists of fresh fruit and vegetables, our body will receive all those vitamins, which are necessary for us. Some vitamins are fat-soluble and can be stored along with fat; some are water-soluble and hence cannot be stored in the body, thus their intake is required continuously.

If a diet is deficient in one or more vitamins, it leads to abnormalities and acute shortage produces diseases. Vitamins are available in the market in the form of capsules, tablets and syrups, and should only be taken on the advice of a doctor.

When vitamins were discovered, their chemical nature was not well known thus they were denoted with english letters as A, B, C, D, E and K. Now it is known that vitamin B is not a single vitamin but a group of vitamins called as **vitamin B complex**. It has eight different compounds as B₁, B₂ etc. Table 10.3 shows different vitamins, their sources, characteristics and functions.



Scurvy



Rickets

Diseases caused by deficiency of vitamins

(Table 10.3) Vitamins and their characteristics

Name of the vitamin	Solubility	Diseases caused by the lack of vitamin	Notes of the diseases	Source of the vitamin
Vitamin A	Fat soluble	Reduced resistance to disease, poor night vision, skin and cornea of the eye becomes dry leading to xerophthalmia	The yellow pigment, carotene present in green leaves and carrots	Milk, butter, cheese liver, cod liver oil and fresh green vegetables.
Vitamin B complex	Water soluble	Wasting or partial paralysis, heart failure, beriberi	Rice husk contains this vitamin, highly milled rice is deficient and population living largely on milled rice, suffer from beri beri and pellagra	Whole grains of cereals, lean meat and yeast.
Vitamin B ₁	Water soluble			
Vitamin B ₂	Water soluble	Skin eczema on exposure to sunlight, diarrhoea, mental degeneration, all symptoms of pellagra		
Riboflavin	Water soluble	Degeneration condition of the skin, particularly around the mouth		Whole cereal grains, peas and beans, liver, kidney, milk.
Vitamin C	Water soluble	Bleeding under the skin, particularly at the joints, swollen, bleeding gums, poor healing of wounds, scurvy.		Oranges, lemons, grape fruit, tomatoes, fresh vegetables, potatoes.

Vitamin D	Fat soluble	Rickets Osteo-malacia	Deficiency of calcium in the bones cause rickets in children. The bones remain soft and are deformed by the child's weight, deficiency in adults causes osteomalacia, the vertebrae are compressed and the legs are bowed	Fish, liver, oils, butter, milk, cheese, egg yolk and liver.
Vitamin E	Fat soluble	Anaemia	Few deficiency effects are apparent in man. Severe deficiency in infants may lead to high rate of destruction of red cells	Green leafy vegetables salad, spinach wheat germ (embryo) meat and dairy products.
Vitamin K	Fat soluble	Blood does not clot	Blood takes longer to clot and may result in fatal in severe cases.	Fresh green vegetables and fruit

5. Mineral Salts

Mineral salts are inorganic compounds which do not provide energy to the body but are needed for the normal chemical activities of the body. Man can obtain them from animals or plants which absorb them from the soil. Some minerals are needed by man and mammals in relatively large quantities, other are required in very small quantities.

Mineral elements play essential role in metabolic activities and are required for better growth and development of the body. Some important minerals which occur naturally in our diet are listed below.

Sodium chloride

It helps to make hydrochloric acid which is very important for the digestion of food. Along with potassium it helps to conduct messages through nerves. It is found in the living cells especially in the red blood cells and muscles, it helps in the growth of the organism. The body acquires it through cereals.

Magnesium

It is an important component of the bones which can be obtained by eating different vegetables.

Calcium

It is required to make bones and teeth strong besides helping in blood clotting, muscular contraction and in the conduction of nerve impulse. It is found in milk, eggs, fruit, cereals and green leafy vegetables.

Iron

A very important mineral which helps to make haemoglobin in the blood. It occurs in meat, liver, eggs, pea nuts, spinach and other vegetables.

Iodine

It is needed by the body in very small amounts which is used to make thyroxine by the thyroid gland. Its deficiency causes goiter. This disease is common in places deficient in iodine. It can be obtained from sea-food, milk, fruit and leafy vegetables.

Flourine

It helps in the growth and development of bones and teeth. If it is mixed in drinking water in suitable amounts, dental decay (caries) can be reduced in children. The body can obtain this mineral from vegetables and fish.

In addition to these minerals traces of cobalt, manganese, zinc and copper are also required for the better functioning of the body.

6. Water

Water makes approximately 70% of the body tissues and is an essential component of the protoplasm. One can live without food for more than a week but a person can die within two to three

days from lack of water. It plays an important role in digestion and transport of digested food and other materials in dissolved form.

We take in water mainly by drinking and from liquid foods. Excretion of urine, removal of faeces and evaporation from the skin and lungs results in 2-3 litres of loss of water per day and this loss is replaced by drinking water. Enzymes become more active in solution form, similarly blood remains thin and can be easily circulated.

Water regulates the body temperature. Its deficiency in the body causes dehydration, which can prove fatal. Plants cannot photosynthesize without water.

The amount of water required by the human body depends upon the human activities and environment of a place – for example people living in hot and dry places need more water. Loss of water takes place during respiration, perspiration and urination, but this loss is compensated by drinking approximately three litres of water by a normal healthy adult. Unusual large intake of water is not advisable in some cases.

Dietary fibre (roughage)

All fruit and vegetables provide fibre to the body- for example, citrus fruits, cereals, spinach, cabbage and salads. The cell wall in plant cells are largely made of cellulose which cannot be digested by man. Bacteria living in the gut of ruminants digest the cellulose and convert it into fatty acids, which renders it absorbable.

Roughage adds bulk to the food enabling the muscles of the alimentary canal to grip it and keeps the food moving by peristalsis. Absence of roughage in our diet may lead to constipation and related disorders. Fibres keep the intestines in a healthy condition, thus our daily diet must contain a lot of fruit and vegetables.

Nutrition and Food Technology

For thousands of years man has been making efforts to grow more food for storage so that it can be used when needed. Modern man knows how to preserve food for use subsequently when needed. Man has adopted modern methods of food preservation in which its nutritional value and taste are preserved. Foods are damaged by bacteria, fungi and other micro-organisms, which occur everywhere. These organisms can contaminate the food material making it unsafe for use and storage, therefore, it is necessary to kill any bacteria or other organisms as soon as they enter food.

Primitive methods of preservation effected the taste of the preserved food, but modern scientific techniques attempt to prevent contamination of food, keep the taste and make it consumable even after a long period of storage. To achieve this, temperature plays an important role.

Food that we take is usually made up of dead tissue and it can be spoiled for two reasons, either the food is contaminated and destroyed by bacteria or fungi or the enzymes still active in tissue start breaking down the cells, thus making food poisonous and tasteless to eat.

All bacteria, fungi and micro-organisms are need to be killed or their growth retarded, in order to protect the food from spoilage. Heat is the best source, as extreme increase in temperature retards bacterial growth and enzyme can also be denatured. Thus temperatures extremes can be useful in the preservation of food.

Methods of food preservation

There are many methods of food preservation, a few are given below:-

1. Pasteurization

This method was discovered by Louis Pasteur to prevent milk from turning sour. Modern pasteurization of milk is based on this discovery. In this process, milk is heated to 71°C for a few seconds and then cooled rapidly. This kills most of the bacteria. The bacteria which survive this treatment may become retarded in growth. In this way, the milk is preserved for a few days.

2. Refrigeration

In this method, food is kept at very low temperature usually below freezing point which can retard the action of enzymes and the growth of bacteria. In deep freezers food can be preserved for many years. Quick freezing helps to maintain the taste and texture of meat, fruit and vegetables.

3. Dehydration

Dried food can be kept safe for a long period at normal temperature. Bacteria can not grow without water, therefore when water content is removed from meat and vegetables, they can be preserved for long durations. Pickling of food is another common indigenous technology in which taste and texture of pickled foods is maintained for long.

4. Canning

In this method the food is first heated at a high temperature that kills bacteria and destroys enzymes, then the food is sealed in a metallic container, thus food becomes safe from contamination. Metallic cans are usually lacquered to prevent food from chemically reacting with metals and producing toxic substances.

10.3.3 Health problems related to nutrition

There can be two problems relating to nutrition

1. Under nutrition
2. Mal-nutrition

These are age-old problems, which at least, one eighth of the humanity is facing. During under nutrition a person's diet is deficient in the required calories. Children are especially affected due to availability of less than normally required diet and suffer from a disease called **marasmus** (Fig. 10.13). In this disease human beings, especially children are reduced to a skeleton as the body becomes completely depleted. Some of the countries for example Ethiopia are famine stricken. Although international community does try its best to rescue the famine inflicted areas, yet it is impossible for them to meet their complete nutritional requirements on such a large scale. The world population is on a continuous rapid rise, it has been estimated that by 2025, the world population will rise to ten billion, whereas water and soil resources are being continuously depleted by



Fig. 10.13 Child suffering from marasmus

increasing use by the continuously growing population. The experts, therefore, envisage that increasing human population if not checked will soon eat up all the food resources of the world which may lead to destruction of human race.

Malnutrition (a diet missing in one or more essential nutrients) also has dire consequences on health, if it continues for a prolonged period, particularly under special circumstances, such as during pregnancy, or immediately after childbirth.

If malnutrition occurs during the period of lactation, it may cause irreparable damage to the infant. During the last quarter of pregnancy when the foetus is rapidly developing its cerebral tissues, a protein deficient diet of the mother can produce mental retardness and nervous abnormalities in fetus, which may prove fatal or lead to permanent disorders. These abnormalities may also occur in infants if the lactating mother is taking a protein deficient diet during the first year of breast-feeding.

If a human diet lacks essential elements or nutrients, the body will fail to synthesize vital compounds, and thus the person will suffer from various diseases. Deficiency of a few amino acids, vitamins, fatty acids, (about thirty compounds) and 21 mineral elements, called as essential nutrients in diet are responsible for various diseases.

In the developing countries like our's packaged or junk food (sugar coated cumin seeds, betel nuts, chewing gums and drinks) are not prepared under proper care. The food colors, scents and flavors which are added to make them commercially attractive are sub- standard and harmful for human health. The use of food additives may be the cause of dangerous diseases like cancer and ulcer etc. These items should, therefore, be avoided.



Fig. 10.14 Balanced diet

Balanced diet

We can call a diet balanced, if the essential dietary components are present in the correct proportion, it helps to maintain health and fulfils the body requirements of an organisms (Fig.10.14).

The degree to which any particular meal is adequate in providing energy from food depends on the nature of the job of a person.

A common man's diet is said to be suitable if it provides fifty percent calories from carbohydrates, forty percent from fats, and ten percent from proteins. Carbohydrates are taken in as foods in abundance as they are readily available and cheaper as compared to fats and proteins. We can live without carbohydrates if our diet has all the components of food and is capable to provide total calories required by the body. Fats are taken in our diet to obtain energy.

Our daily food requirement varies with sex, age and occupation- for example children need more food because they are growing. Youth need more food than elderly people due to physical exertion. Men need more food than women. Pregnant women, lactating mothers and convalescents need more food as compared to others.

Ingestion and Digestion of Food in Man

You have already studied that the food prepared by plants is in the form of glucose. Energy is obtained from glucose to carry out various functions. Plants synthesize different organic compounds from this glucose.

The matter is different in animals. Their diet consists of complex organic compounds and their molecules cannot pass through cell membranes. Therefore, it is necessary that the large and complex molecules must be broken down into simple form and converted into molecules, simple enough to be used by the cells. The food that we eat passes through three phases before it can be used by the body for energy requirement and other purposes. These three stages are:-

- a. **Taking in of food (ingestion)**
- b. **Digestion**
- c. **Assimilation**

The food of animals and humans is in solid form and may be bulky. Taking in of the food in the oral cavity and swallowing is called **ingestion**. During this process the raw food material is first broken into small pieces, by the chewing action and is changed into small particles.

Teeth

Nature has blessed animals and human beings with teeth which help in breaking and chewing food. Teeth are attached to the upper and lower jaws. Humans have two sets of teeth during their lives. The first set of teeth begins to come through the gums when the baby is about six months old. These are called the **milk teeth** and all twenty teeth are formed over a period of two years. The milk teeth begin to drop out at the age of six years and are gradually replaced by the second set of teeth called the **permanent teeth**. In man the milk teeth do not fall off simultaneously, they fall off one by one and similarly permanent grow one by one as well. Healthy teeth are strong and give a beautiful and lustrous look. If we look at a tooth which has been extracted by a dentist, you will see the following parts. (Fig 10.15)

Structure of a tooth

A tooth has two permanent part **i) Crown.** **ii) Root**

The crown is that part of tooth which projects out of the gums and jaws. The root of the tooth is embedded into the gums and is, therefore, hidden.

1. Enamel

This is the outer most, hard layer which gives lustre to the tooth. It is deposited on the outside of the crown of the tooth by cells in the gum. The enamel is a non-living substance made of calcium salts. It imparts beauty to the tooth and being hard protects the tooth. If the enamel gets removed then the teeth start decaying.

2. Dentine

Under the enamel is the dentine layer which is hard but it wears off if the enamel gets removed. Running through the dentine are strands of cytoplasm arising from the cells in the pulp. These cells keep on adding more dentine to the inside of the tooth.

3. Pulp

The innermost part of the tooth is made up of soft connective tissue and is called the pulp. The strands of cytoplasm in the dentine derive their food and oxygen from the pulp which enables the tooth to live and grow. Besides these, the pulp contains sensory nerves and blood capillaries. These nerve endings are sensitive to heat and cold and can produce the sense of pain i.e tooth-ache.

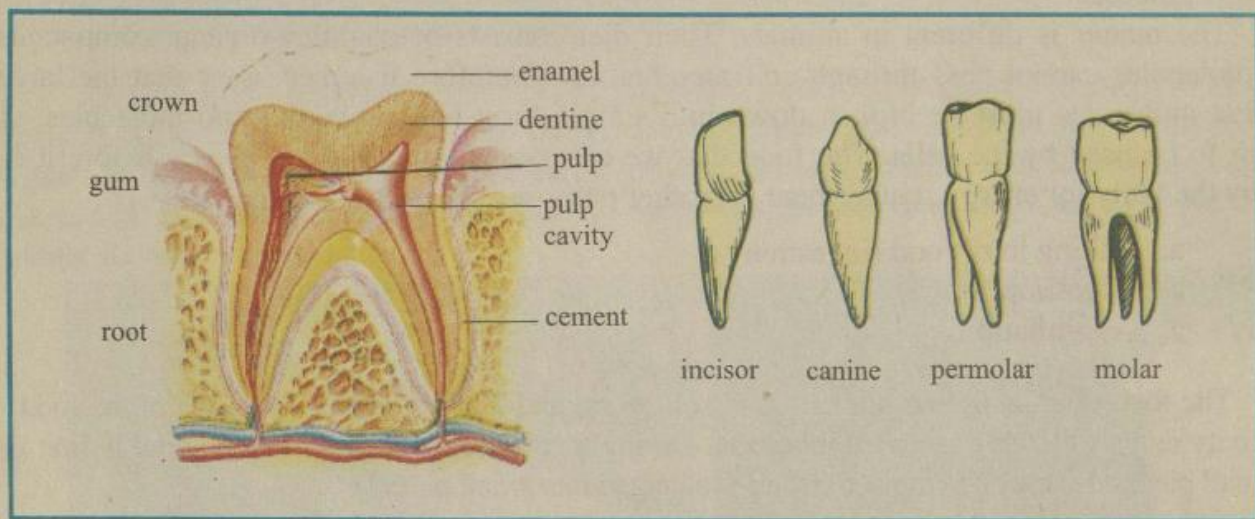


Fig. 10.15 Structure of a tooth

4. Cement

It is a thin layer of very hard material covering the dentine at the root of the tooth. The fibres which hold the tooth in the jaw are embedded in the cement at one end and in the jaw at the other. Thus teeth remain firmly embedded in the jaws.

The causes of tooth decay and its prevention

Teeth are a gift of nature. If we wish our teeth to remain healthy, we should wash and clean them after every meal. Our tongue is helpful in cleaning the upper portion of teeth to some extent. But if food particles are firmly trapped up between the teeth, or between gums and teeth, then it becomes difficult to remove them with the tongue. The main cause of tooth decay is a sugar coating left by sugary food on the teeth, which is converted into acid by bacteria. The acid damages the enamel and allows the bacteria to infect the soft dentine and reach the pulp cavity. The dentine starts decaying and causes toothache. Sugary foods such as sweets, toffees and chocolates, the bacteria which cause decay, form a thin layer of **scum** over the surface of the teeth. This layer becomes very hard with the passage of time and is difficult to remove. This scum is called **plaque**.

In order to avoid plaque, the teeth should be cleaned properly and regularly with a miswaak or a tooth brush. We should eat less sugar, or sweet and sticky foods and also clean the teeth afterwards. Balanced diet should be taken, especially by young people who have growing teeth.

Types of teeth

When a child is about six or seven years old, the milk teeth begin to drop out and are gradually replaced by the permanent teeth. On examination of buccal cavity, four different types of teeth are seen, which are different in shapes according to the function they perform (Fig. 10.16).

1. Incisors

The incisors are the front teeth in both the jaws. They are eight in number, four in each jaw. They are chisel shaped and are used for cutting food.

2. Canines

They are four in number in both the jaws that is one canine on each side of the incisors. They are very strong and pointed, used for gripping and tearing food. These canines are very prominent in carnivores like cat, dog or lion. The canines are used to catch and grip the prey and to tearing the flesh canines are very prominent in carnivores like cat, dog or lion. The canines are used to catch and grip the prey and help in tearing the flesh.

3. Molars

The teeth behind the canines are called the molars. They are of two types. premolars and molars (also called as back teeth). There are four premolars and six molars in each jaw. A premolar has two roots while a molar has three. These are very strong teeth having a flattened surface with ridges. They are used for crushing and grinding food. The last molar in each jaw is called the **wisdom tooth** which makes its appearance after adolescence.

The arrangement of the teeth can be shown by a dental formula:

$$I \ 2\frac{1}{2} \quad C \ 1\frac{1}{1} \quad Pm \ 2\frac{2}{2} \quad M \ 3\frac{3}{3}$$

This formula shows the number of each type of tooth in half of the upper jaw and half of the lower jaw.

10.4 Digestion of Food in Man

By now you have understood the important role played by teeth in the process of nutrition. The teeth crush and break the food and convert it into small particles. The tongue rolls the morsel of food and push it under teeth again and again so that the food is evenly divided into fine particles and the saliva secreted from the salivary glands gets mixed with the food. The saliva lubricates the food and makes the particles adhere to one another, forming a ball of food called **bolus**. Now the chemical digestion of food starts. Saliva contains an enzyme to digest starch in the food. The combined action of teeth, tongue and saliva pushes the bolus through the throat into the oesophagus, and then it goes into stomach.

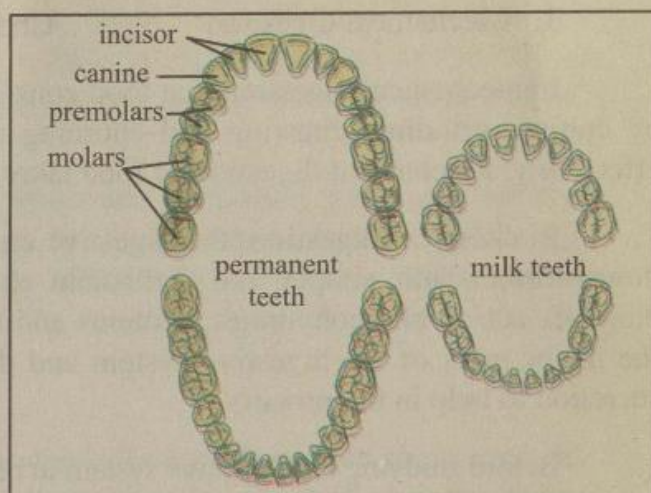


Fig.10.16 Dentition of man

Digestion is the process in which the insoluble and non-diffusible components of food are broken down and by the action of enzymes are converted into soluble and diffusible substance to be absorbed into the blood stream. The process of digestion can be divided into two parts.

1. Mechanical digestion 2. Chemical digestion

In mechanical digestion, the food consisting of large sized particles is broken into fine pieces by cutting, grinding, chewing and churning up, so that enzymes can act upon it efficiently and effectively. Mechanical digestion of food takes place in the mouth and stomach.

In chemical digestion, the digestive enzymes mix with the food and act upon it to break it down further into simple and diffusible chemical forms. During chemical digestion different enzymes act on carbohydrates, proteins and fats separately. Chemical digestion takes place in all the major parts of the digestive system and digestive glands like liver and pancreas pour in their secretion to help in the process.

Before studying the digestive system in detail, let us know about enzymes in more detail.

Enzymes

Enzymes are chemical compounds, which are protein in nature. They are made by living cells. They are not consumed in a reaction, they act as a catalyst as they only speed up chemical reactions. Most of the enzymes are **intracellular**, that is, they work within a cell, in which they are produced. Whereas some enzymes are secreted out of the cells where they work. They are called **extra-cellular enzymes**. Bacteria and fungi secrete such extra-cellular enzymes into the medium in which they are growing. The higher organisms secrete extra-cellular enzymes into the lumen of alimentary canal to act on the food.

The enzymes which act on starch are called **amylases**, those acting on proteins are called **proteinases**, while those acting on fats are called **lipases**.

Enzymes have a few characteristics, which are as follows.

1. All enzymes are protein in nature, they can be destroyed by heating.
2. They act best within a narrow temperature range.
3. They work efficiently in narrow range of acidity or alkalinity.
4. A particular enzyme forms the same end-product, because it acts on a particular/ specific substrate.

Human Digestive System

All living beings need food to live and to carry on their life functions. Animals are unable to prepare their food, therefore, they depend on plants for their food requirements. Digestion is the process in which the non-diffusible molecules of food are changed to diffusible ones by the action of enzymes and the organs which take part in this process make a system called the **digestive system**.

The process of digestion takes place in the alimentary canal, which begins from the mouth and ends at the anus. The tube assumes different shapes according to their role in the process of digestion. It consists of the mouth, oesophagus, stomach, small intestine, and large intestine. Besides these organs liver and pancreas, also play important roles in digestion. The muscles of the

alimentary canal produce rhythmic waves of contraction called **peristalsis**, which push the food all along the alimentary canal.

Digestion of food in the mouth

During mastication the food is mixed thoroughly with the saliva while the food is in the buccal cavity. The saliva is secreted by three pairs of the salivary glands located in the buccal cavity. The saliva is continuously secreted by the salivary glands in response to the presence of food in the buccal cavity.

Saliva is alkaline and contains an enzyme **ptyalin** which acts on starchy parts of foods and converts it into sugar (maltose). Doctors advise us to chew the food properly before swallowing. Why? The morsel of food after being chewed and thoroughly mixed with the saliva is called a **bolus** (round mass) is rolled down by the swallowing action into the oesophagus which conveys it to the stomach by the wave of peristalsis.

Digestion of food in the stomach

Stomach is a thick, muscular sac like structure, in which food is stored for some time. Its inner surface has numerous glands called **gastric glands**, which secrete a juice called **gastric juice**. Human stomach secretes about one to two litres of this juice daily. Gastric juice contains hydrochloric acid and two enzymes, renin and pepsin. **Hydrochloric acid** changes the medium of food to acidic, which kills the bacteria, that may be present in the food. The **pepsin** acts on proteins and breaks them down into peptones. **Renin** helps to curdle milk in infants. There is no chemical action on carbohydrates and fats present in food. The regular movements of the stomach churn up the food with the action of gastric juice, and thus food is changed into a thick fluid called **chyme**. When digestion in the stomach is complete, the distal end of the stomach called the **pyloric end** relaxes, and allows a small amount of chyme to pass into the first part of the small intestine (Fig.10.16).

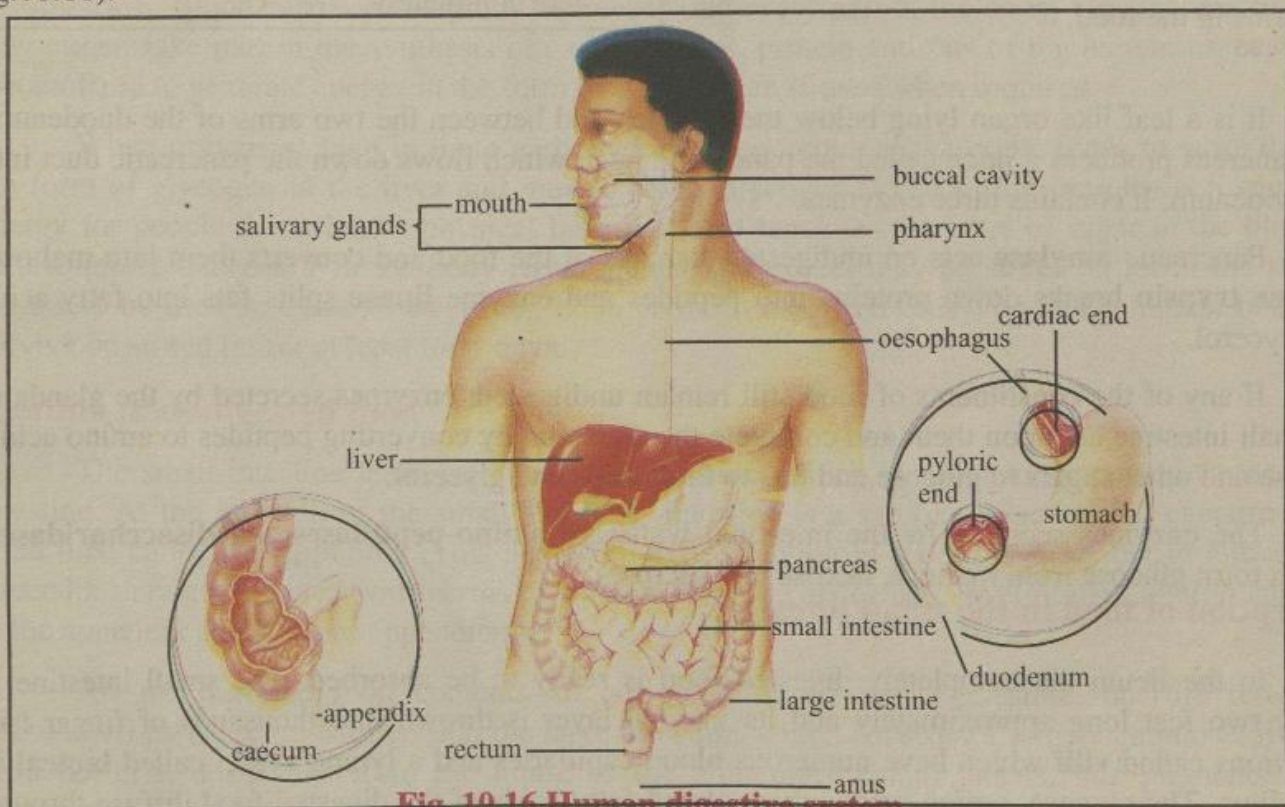


Fig. 10.16 Human digestive system

Digestion and absorption of food in the small intestine

The first part of the small intestine is called the **duodenum**, an alkaline juice from the pancreas and bile juice from the liver are poured into the duodenum by a common duct. Both the juices contain bicarbonates which neutralize the acidic chyme and make it rather alkaline. Besides these juices other intestinal juices from the walls of the small intestine are also poured. All these juices act on food.

Liver

The liver is a large reddish-brown organ; which lies just below the diaphragm on the right side of the body under the ribs. It is divided into five lobes, three on the right side and two on the left. The cells of the liver secrete a greenish-yellow alkaline fluid called the **bile juice**. It contains bile salts and bile pigments which give greenish yellow colour to the juice. Bile contains no digestive enzymes, but it does contain bile salts which break down the large molecules of fats to small fat droplets. This process is called **emulsification**. This helps in the fats to be digested easily. Bile juice also contains bile pigments that are by products of red cells, these pigments are eliminated from the body with the faeces, and the colour of the faeces is due to these pigments. Besides this, bile juice also kills the germs in the food.

Pancreas

It is a leaf like organ lying below the stomach and between the two arms of the duodenum. The pancreas produces a juice called the pancreatic juice which flows down the pancreatic duct into the duodenum. It contains three enzymes.

Pancreatic **amylase** acts on undigested starches of the food and converts them into maltose. Enzyme **trypsin** breaks down proteins into peptides and enzyme **lipase** splits fats into fatty acids and glycerol.

If any of the constituents of food still remain undigested, enzymes secreted by the glands in the small intestine act upon them and complete the digestion by converting peptides to amino acids, maltose and other sugars to glucose and fats to fatty acids and glycerol.

The enzymes secreted by the intestinal walls are **amino-peptidases** and **disaccharidases**, (which form glucose from maltose, lactose and sucrose).

Absorption of food in the small intestine

In the ileum the completely digested food is ready to be absorbed. The small intestine is twenty two feet long approximately and its internal layer is thrown into thousands of finger like projections called **villi** which have numerous blood capillaries and a lymph vessel called **lacteal** in each villus. The glucose, amino-acids, glycerol and fatty acids of the digested food diffuse through the lining of small intestine into the blood stream and lacteal. This process is called **absorption**.

Functions of Liver

1. Liver stores glycogen and regulates the level of glucose in the blood.
2. It breaks down excess amino acids this is called de-amination.
3. It is involved in detoxification.
4. It produces and secretes bile juice which is stored in the gallbladder.
5. It metabolizes carbohydrates, fats, proteins and other compounds.
6. As a result of chemical changes a lot of heat is produced, therefore liver helps to keep the body warm.
7. It makes fibrinogen and other blood proteins.
8. Damaged red blood cells are decomposed here completely.

All carbohydrates are absorbed in the form of glucose, fructose, and galactose. Proteins are absorbed in the form of amino acids. The small molecules of the digested food, principally amino acids and glucose pass through the epithelium of the capillary walls and enter the blood plasma. Some of the fatty acids and glycerol from the digestion of fats, do not enter the blood capillaries of the villi, instead they enter and recombine in the intestinal lining to form fats again, and then these fats pass into the lacteals. The fluid in the lacteals enters the lymphatic system and eventually empties its contents into the blood stream through the thoracic duct, (Fig. 10.17).

Practical work: Section of a villus

Take a slide showing a transverse section of human small intestine and observe it under a microscope. The entire inside surface of the ileum is covered with finger-like projections called villi. In side each villus is a net work of blood vessels and a lymph vessel or lacteal. The outer most wall of the villus is made up of one celled thick epithelium, through which nutrients can diffuse easily.

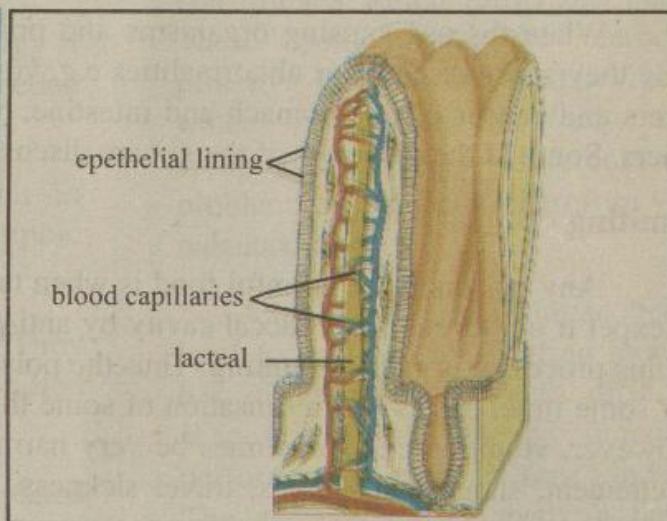


Fig. 10.17 Structure of a villus

Assimilation of digested food

You have studied that the products of digestion are finally absorbed through the lining of small intestine into the blood stream and become a part of the cell components, this is called **assimilation**. Blood carries these products to each and every part of the body. On reaching the cells they either, take part in the synthesis of carbohydrates, protein and fats of the human tissue, or are metabolized to generate energy in the form of ATP, which is used when required.

When organisms take in more carbohydrates than required the body, tends to store them in the form of glycogen in the liver and muscle cells. Glycogen stored in the muscles is a source of energy for people doing heavy physical labour. It also regulates the level of sugar in the blood. If caloric intake exceeds than the body requirements, the excess may be stored as fat in the storage organs to be used in cases of starvation or in crisis. It has been observed that a human body can survive on stored fat for at least forty days.

Egestion of undigested food

The small intestine leads into the large intestine, which is wider as compared to the small intestine. At the junction of the small and large intestine is a sac like structure the **caecum** and a blind tube called the **appendix**. This has no specific function in food digestion, but in humans the appendix may get infected with germs or foreign bodies. This causes severe inflammation and pain in the appendix and leads to appendicitis.

All the digested food contents are absorbed in the small intestine, but the remaining unabsorbed parts are transferred into the large intestine, which consists of largely cellulose, live and dead bacteria, dead cells from the lining of the alimentary canal, mucus, bile pigments, small amounts of nitrogenous wastes and water. As materials pass along the colon, water is absorbed from it. The unabsorbed matter, bacteria etc., become more solid. This solid matter then passes on to the

rectum, as faeces. Eventually, the faeces are expelled out through the anus. This process is called **egestion**.

The mesentery holds the various organs of digestive system in their right places to avoid clumping of the intestines.

Disorders of the gut

When disease causing organisms and poisonous substances have a chance of entering the body they cause diseases or abnormalities e.g. vomiting, diarrhoea, constipation, cholera, dysentery, ulcers and cancer of the stomach and intestine. Some of these abnormalities are more severe than others. Some of the disorders of the gut are discussed below.

Vomiting

Any poisonous or harmful food is when taken in and goes to the stomach, the stomach tends to expel it out through the buccal cavity by anti-peristaltic movements. When it actually comes out in this process it is called vomiting. Thus the poisonous matter is expelled out and one can feel relief for some time. If it is just a sensation of some thing coming out of the stomach it is called **nausea**. However, vomiting can sometimes be very harmful as well. Vomiting can also be caused by over excitement, shock, bad smells, travel sickness, pregnancy or on accounts of some diseases like malaria etc.

Diarrhoea

Diarrhoea is usually caused when food in the colon is infected by bacteria or is contaminated with toxic matter. The result is loose, watery frequent motions. As there is not enough time for the water to be re-absorbed by the epithelium in the large intestine, the faeces therefore, come out in a semi-liquid rather than a semi-solid form. However, diarrhoea can be serious if it goes on for a long time as too much water and salts are lost from the body leading to dehydration of the body. In such a state one should immediately start taking 'ORS' and seek medical aid. The cause of diarrhoea should be removed as soon as possible.

Constipation

This problem is the opposite of diarrhoea. The faeces moves too slowly along the large intestine, with the result that more water is absorbed from the faeces than usual and thus it becomes hard and dry. This makes it difficult and painful to pass out through the anus. Doctors usually suggest laxative for example, paraffin, this makes the faeces soft to be discharged easily. Constipation is also called as the mother of all diseases. It can be avoided by drinking plenty of water (fluids) and eating more fibrous food i.e. fruit and vegetables.

Thread worms

This disease is usually more common in children. Threadworms are parasites, which live in the large intestine. At night the females travel down to the anus and lay eggs. This causes itching (irritation) around the anus. When the person scratches, the eggs enter the nails. If the food is handled with such contaminated hands, the eggs are transferred from food to other persons. Thus the disease spreads from one individual to the other. Even the adults can suffer from this problem. To avoid this, the proper medicines under the advice of the doctor may be taken and hygienic and healthy habits should be adopted.

KEY POINTS

1. All living beings need food, because it is a source of energy. Food helps to make new protoplasm needed by living things to grow, repair and build cells and tissues and maintain health.
2. The process of acquiring food and energy is called nutrition and the components needed for it are called nutrients.
3. There are two methods of nutrition in plants, autotrophic nutrition and heterotrophic nutrition.
4. All green plants are autotrophs. They prepare their food by a process called photosynthesis.
5. The process of photosynthesis is completed in two stages, called light and dark reactions.
6. Photosynthesis is mostly carried out in the leaves, which is anatomically well adapted for the process to take place.
7. Photosynthesis not only affects the environment, but animals as well as man are also dependent on photosynthesis.
8. Plants absorb water and mineral salts from the soil, which are very essential for their growth and development.
9. Although capable of photosynthesis, some green plants take in food in an organic form, to supplement their food.
10. Animals are unable to prepare their food, therefore, they depend on the plants directly or indirectly to meet their nutritional requirements, this mode of nutrition is called holozoic mode.
11. Our food consists of chemical constituents which fulfil our body needs. These components are carbohydrates, proteins, fats, mineral salts, vitamins and water. Deficiency of any of these compounds leads to different nutritional problems in the body, therefore we need a balanced diet.
12. Allah has blessed human beings with teeth to cut, smash and grind food. A tooth has different parts. Teeth differ in their shapes according to the functions they perform, thus there are four kinds of teeth. The arrangement of teeth in the jaws is represented by the formula:

$$I \frac{2}{2}, C \frac{1}{1}, Pm \frac{2}{2}, M \frac{3}{3}$$
13. The digestive system is made up of organs, which help in the digestion of food. The process of digestion of food is not completed unless large and complex molecules of food are broken down by the action of enzymes into diffusible molecules of food. Therefore, digestion is completed in two processes: mechanical digestion and chemical digestion.
14. If food is not properly digested or becomes contaminated then certain disorders are produced like vomiting, diarrhoea.

QUESTIONS

1. Fill in the blanks:

- (a) The process of acquiring food and ----- is called nutrition.
- (b) Plants prepare their food by the process of -----.
- (c) Food is prepared in the ----- cells of plants.
- (d) The formula of simple sugar is -----.
- (e) The basic units of proteins are called -----.

2. Write whether the statement is 'true' or 'false'. Correct the statement if it is false.

- (i) Saliva is acidic in nature.
- (ii) Sodium chloride plays an important role in making the bones and teeth strong.
- (iii) The problems arising due to the deficiency of food is called under nutrition.
- (iv) When milk is boiled for a few seconds to 71°C and cooled rapidly, the process is called refrigeration.
- (v) Human jaws have four incisors in total.
- (vi) The portal vein carries sugar and amino acids to the liver.
- (vii) Gastric juice contains an enzyme trypsin besides hydrochloric acid.

3. Each question is followed by four options. Encircle the correct answer.

- (i) Proteins are found in:
 - (a) Butter (b) Potatoes
 - (c) Meat (d) Bananas
 - (ii) In plants excess food is stored in the:
 - (a) Leaves (b) Roots
 - (c) Stems (d) 1, 2 and 3
 - (iii) Following enzymes are found in the gastric juice:
 - (a) Pepsin, HCl (b) Pepsin, Alkali
 - (c) Ptyalin, Alkali (d) Pepsin, Ptyalin
 - (iv) Vitamin A is found in:
 - (a) Tomatoes (b) Leafy vegetables
 - (c) Butter (d) Carrots
 - (v) Water is absorbed in:
 - (a) Stomach (b) Large intestine
 - (c) Small intestine (d) Pancreas
4. Give short answers to the following:
- (a) What do you understand by nutrition? Name the nutrients.

- (b) Write the function of stomata and guard cells.
- (c) What do you understand by macronutrients? Name them.
- (d) Write down three functions of the liver.

5. What do you understand by the term photosynthesis? Express the process by a formula. What are the conditions necessary for photosynthesis? Explain their importance.

6. How is the external and internal structure of the leaf adapted to the process of photosynthesis?

7. Prove with the help of an experiment that light and chlorophyll are necessary for photosynthesis?

8. How will you prove that oxygen is released during the process of photosynthesis?

9. Draw and label different parts of a human tooth?

10. What is the importance of vitamins, Explain.

11. Write a note on the following:

- (a) Pasteurization (b) Canning
- (c) Diarrhoea (d) Constipation

12. What do you mean by light and dark reactions? Explain in detail.

13. What are the basic constituents of food? How are they important to us?

14. Define digestion? Explain how enzymes act on different constituents of food.

15. Explain the structure and kinds of teeth in humans. How can we prevent our teeth from tooth decay?

RESPIRATION AND GASEOUS EXCHANGE

In this chapter you will learn:

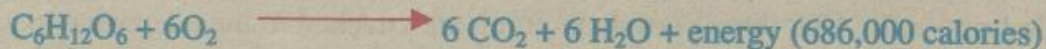
- Definition of respiration and its different aspects.
- Formation of ATP molecule and use of energy by organisms.
- Explanation of aerobic and anaerobic respiration with the help of simple experiments, and importance of anaerobic respiration.
- Gaseous exchange in plants.
- Gaseous exchange in animals.
- Structure and function of human respiratory system.
- The effect of smoking.



11.1 Respiration

The organism require energy to perform their normal activities. This energy is obtained by metabolizing the food that they eat. Green plants prepare their own food from carbon dioxide and water in the presence of sunlight by a process called **photosynthesis**. Whereas animals eat the already prepared food.

How do the digested food provide energy? The products of digestion viz glucose, amino acid and fatty acids etc contain chemical energy in them. When these compounds are metabolized and degraded, a large amount of energy is usually released. For example, a molecule of glucose on complete oxidation releases 686,000 calories.



This energy is utilized in carrying out the normal activities of organisms, as for example, contraction of muscles which brings about movement and beating of heart etc. Mostly a single activity requires considerably less energy for its accomplishment, than is released from a complete oxidation of a glucose, protein or fatty acid molecule. The nature has, therefore, devised a system in which the chemical energy of glucose, protein and fatty acid on degradation (catabolism) is trapped into small packets of energy in the form of ATP molecules. A molecule of ATP on its breakdown releases only 7300 calories of energy. Many ATP molecules, as required for a particular activity,

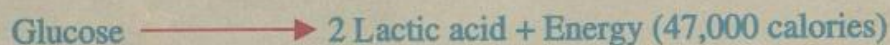
can be made available to provide the energy needed. This is the most economical arrangement of nature.

The oxidation of the absorbed food material in order to obtain energy is called **respiration**.

There are two methods of respiration in the organisms.

Some organisms oxidize their food without using any molecular oxygen. This is known as **anaerobic respiration**. In this type of respiration considerably less amount of energy is produced as compared with the other type of respiration.

In anaerobic respiration a glucose molecule is broken down into two molecules of lactic acid with a release of only 47,000 calories of energy.



In most of the higher and larger organisms, the glucose etc is oxidized by using molecular oxygen. This type of respiration is known as **aerobic respiration**. In aerobic respiration a mole of glucose is oxidized completely into carbon dioxide and water releasing enormous amount of energy. One glucose molecule in this respiration produces 686,000 calories of energy. Aerobic Respiration thus produces 20 times more energy than the anaerobic respiration.

11.2 Aerobic Respiration

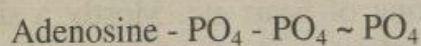
There are two stages of aerobic respiration in the first stage the organisms take the air (containing oxygen) into their bodies. This is called **external respiration**. This stage includes the transport of oxygen obtained from the inhaled oxygen to each cell of the body.

The second stage which is called **internal respiration** consists of the oxidation of glucose, amino acid and fatty acids etc., with molecular oxygen. In this stage all these reactions are included which extract the chemical energy of glucose and other compounds and store it in the form of ATP molecule, this respiration is also known as **cellular respiration** as it occurs within cells.

In the internal or cellular respiration glucose and other compounds are passed through such enzymatic reactions which release the chemical energy gradually in small amounts, with the help of which ATP molecules are synthesized.

11.3 Adenosine Triphosphate (ATP)

ATP is an abbreviation of adenosine tri-phosphate. Its name indicates that it contains adenosine and three phosphate groups. Adenosine is formed of a nitrogenous base called adenine and a sugar called ribose. In ATP three phosphate group are attached to the adenosine in a series one after the other.



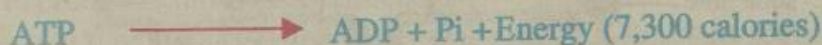
The two terminal bonds between the phosphate groups contain large amount of the chemical energy. When these bonds are broken in enzymatic reaction, large amount of energy is

A human being (man) who weighs 70 kg, stores 12 kg of fats. 34 % of the energy produced during respiration is used to maintain the body temperature constant and remaining 66% of energy is used for other body functions.

One should not remain without food for one week. During fasting 2kg of fats are used in three days. In the first week ½ kg of protein is used. Protein is not stored in the body. During fasting when glycogen and fats are completely used then protein of muscle fibers gets dissolved.

released by which energy requiring activities are accomplished, such as synthesis of various compounds like carbohydrates, fats, proteins and hormones etc or for carrying out any physical work like muscle contraction, heat production or transport of substances etc.

When the terminal bond is broken the ATP is converted into ADP and phosphate, with a simultaneous release of 7,300 calories.



ATP is an energy currency and wherever energy is required in the cell, the ATP energy can be made use of.

Practical work:

Release of energy in the form of heat during respiration

1. Arrange the apparatus as shown in the figure.(11.1)
2. Take pea-seeds and soak them in water for twenty four hours.
3. Wash the seeds with some germicide (01% chlorine or sodium hypo-chlorite solution) to kill bacteria or fungi present on the seeds.
4. Take some seeds and boil them for about 10 minutes to kill the cells.
5. After cooling them wash with dilute germicidal solution to protect them from rotting due to high temperature.
6. Put these two types of seeds in two separate vacuum flasks. Take care not to fill the flask up to the mouth. Insert a thermometer in each flask and plug them with cotton wool.
7. Place them in the stands with mouths downwards. Note the temperature of both the thermometers and answer the following questions.
 - i- In which flask the temperature is higher, give reason?
 - ii- Why were both the flasks placed in inverted position?
 - iii- Why flasks not filled with seeds up to the mouth.

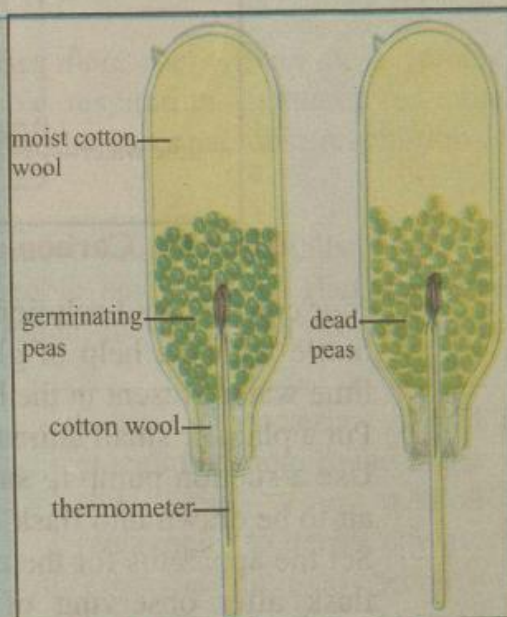


Fig. 11.1 Heat energy is given out during aerobic respiration

Table 11.1

	Aerobic respiration	Anaerobic respiration
Oxygen is necessary	Yes	No
Amount of energy released from 1gm glucose	36 ATP (2830 KJ)	(2ATP) 118 KJ
Chemical products	CO ₂ +H ₂ O(in organic compounds)	Lactic acid and alcohol (organic compounds)
Enzymes (are to be found)	In mitochondria	Usually in cytoplasm
Importance	Source of energy for organisms	Provide energy during fermentation and when there is deficiency of oxygen. It helps in bread making and production of alcohol.

Practical work: Release of carbon dioxide during aerobic respiration

1. Set up the apparatus as shown in the diagram given below.

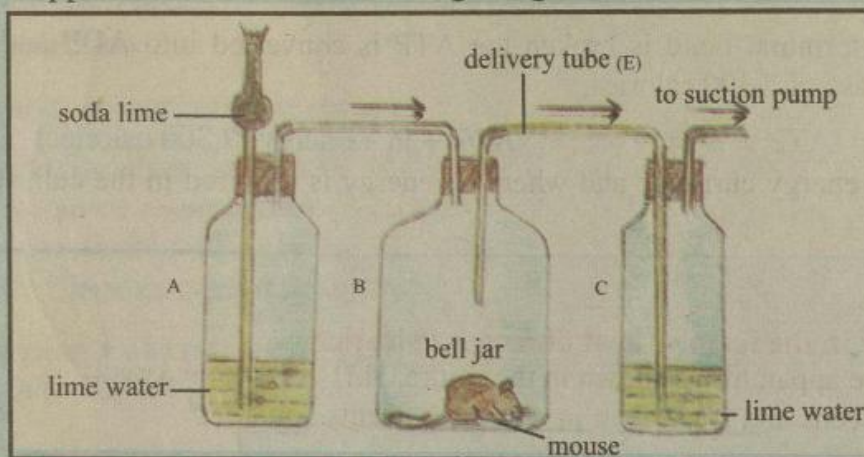


Fig. 11.2 Carbon dioxide is given off during aerobic respiration

2. Pour concentrated solution of soda lime (KOH) in the U tube and set it in the bottle with the help of glass tube in such a way that it is in contact with the lime water present in the bottle.
3. Put a plant or small animal (mouse) under the conical flask.
4. Use a suction pump to suck out the air through delivery tube (E). This causes air to be drawn into flask A.
5. Set the apparatus for the control experiment and tell what will you place in the flask after observing of the results of both experiments and answer the following questions.
 - a. What is the purpose of using KOH (soda lime)?
 - b. Why is lime water used?
 - c. What is the change in lime water and what is the reason for this change?
 - d. If a plant is used in this experiment why it is covered with black cloth?

Practical work: Anaerobic respiration in yeast cells

1. Set up the apparatus as shown in the diagram
2. Heat 5% suspension of dried yeast, and place it in a test tube.
3. Cover with a thin layer of liquid paraffin to exclude atmospheric O_2 from the mixture.
4. A delivery tube is fitted as shown in Fig. 11.3 and allow to dip into clear lime water in a glass tube.
5. Gently heat the tube containing glucose and yeast solution for 10-15 minutes.

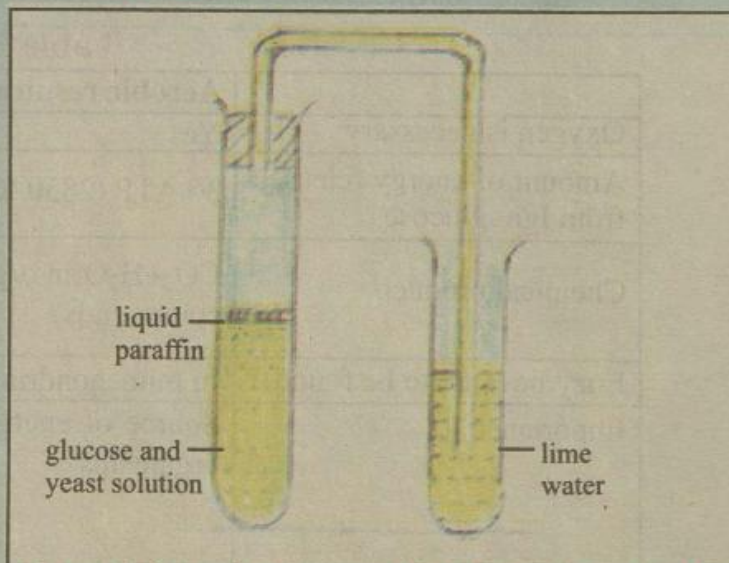


Fig. 11.3 Anaerobic respiration in yeast cells

6. Set up the control experiment observe the changes in both set ups. Answer the following questions.
- What will be poured in the test tube in the control experiment?
 - Why are the yeast cells heated in the first experiment?
 - Why is the mixture covered with paraffin?
 - Which gas is produced in this experiment?
 - What changes in the colour of lime water was noted? What is its reasons?

11.4 Importance of Anaerobic Respiration

You have studied that aerobic respiration produces 15 times more energy than the anaerobic respiration. The advantage of aerobic respiration over anaerobic respiration is, therefore, quite evident. So you can see why large organism have aerobic respiration. But anaerobic respiration is also important in its place because of the following reasons:-

1. The planet of earth in its early time had an environment which was totally devoid of oxygen. The aerobic organism can not exist in anaerobic environment. Had the early organism on earth been incapable of anaerobic respiration, the life perhaps could never have originated?
2. Some existing organisms like bacteria and parasites which live in oxygen environment have anaerobic respiration. Many useful bacteria and yeasts are anaerobic.
3. Even in the aerobic respiration the first phase is anaerobic. The glycolysis which is the first phase of carbohydrate metabolism involves reaction which do not require the expenditure of molecular oxygen. This may in a way support the notion that aerobic organisms have evolved from the anaerobic organisms?
4. In some active tissues like skeletal muscles, although aerobic metabolism takes place but in sustained activity when the oxygen supply can not keep pace with the energy demand, anaerobic respiration supplies the energy continuously by the breakdown of glucose to lactic acid.

Some bacteria and unicellular fungi found in the soil have same method (anaerobic) to derive energy. Yeast is used to produce "khameer" in the flour to make bread. Souring of butter is due to butyric acid which is produced due to a bacteria. In some animal the same method is used.

Oxygen debt

In a rapid and strenuous exercise, the rate of breathing becomes fast but it does not supply enough oxygen to the muscle to meet the increased energy demand. Hence anaerobic respiration i.e. glycolysis continue to supply the energy to meet the demand to some extent but this leads to an accumulation of lactic acid in the muscles. This is called **muscle fatigue**.

You may have noticed that fast breathing continue for some time after the strenuous exercise has been stopped. This is done for paying off the oxygen debt the muscle has incurred during prolonged continuous exercise. This additional supply of oxygen is used to oxidize some amount of lactic acids which releases energy with which the remaining amount of lactic acid is converted back into glucose.

11.5 Gaseous Exchange in Plants

Plants get their energy from respiration. The respiration is, therefore, also important for life of plants. Plants have no special organ or system for exchange of gases. The gaseous exchange in plants occur in cells of every part of the plant i.e. roots, stems and leaves etc according to their energy demands. The conducting system (xylem & phloem) of plants for water and nutrients is not involved in the diffusion of gases to the plants. The air spaces present between the cells of parenchyma of leaves, stem and roots are involved in the gaseous exchange. In the leaves and young stems, gaseous exchange occurs through stomata and some exchange of gases also occurs through cuticle (Fig. 11.4).(Fig. 11.5).

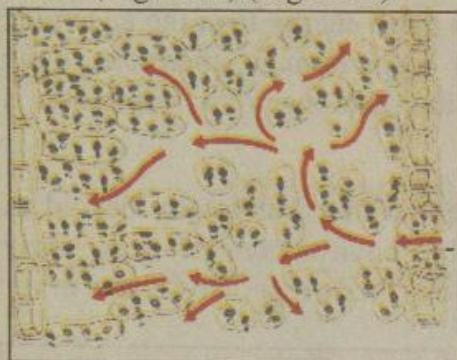


Fig. 11.4 Gaseous exchange in leaves

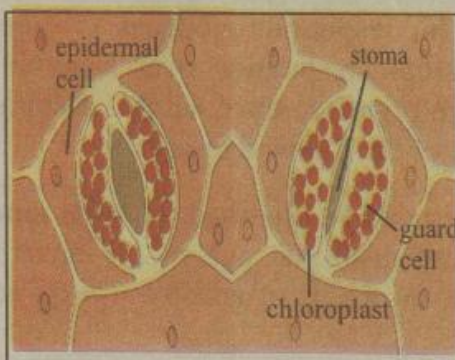


Fig. 11.5 Opening and closing of stoma in leaves



Fig. 11.6 Lenticels in old stem

In woody stems and roots there are dead cells beneath the epidermis which form cork tissue. This tissue has pores called **lenticels** which are involved in gaseous exchange (Fig. 11.5). The aquatic parts obtain oxygen for their respiration by diffusion from the dissolved oxygen in water. Whereas the land plants get their oxygen from air directly through their stomata which are more abundant on the lower surface than the upper surface of leaves. The roots get their oxygen for gaseous exchange through diffusion from the air existing in the space between soil particles. (Fig. 11.7).



Fig.11.7 Gaseous exchange through roots

Process of Respiration

The respiration in plants continues day and night. In this process, the oxygen from the airspaces in the leaves and stems diffuses into tissues and cells of the plants after getting dissolved in the film of water present over the cells. In the cells this oxygen oxidizes the carbohydrates and other organic compounds into carbon dioxide and water to produce energy. Some of this carbon dioxide is used in photosynthesis. The rest of the carbon dioxide and some of the water (vapours) collect in the airspaces from where they pass out to the exterior through lenticels and stomata. The elimination of carbon dioxide is more evident from the parts without chlorophyll like growing seeds and buds. The water produced in this process also becomes a part of the already present water in the body of plants.

As in animals the process of oxidation (respiration) in plants consists of many enzymatic reactions. This process occurs at a faster rate in the parts of the plant having rapid growth like growing seeds, buds, apical meristem of roots and shoots, because these parts require more energy to accomplish the growth process.

The gaseous exchange in plant is not very evident during the day time as the products of respiration i.e. carbon dioxide and water are the reactants in the process of photosynthesis. So the carbon dioxide and water produced in the respiration are utilized in photosynthesis, occurring in the day light. In the bright sunshine, because of high rate of photosynthesis the carbon dioxide produced in respiration falls short and therefore, some carbon dioxide has to be taken into the plant from outside for photosynthesis.

In the day time the plants therefore, takes in carbon dioxide and expel out oxygen. The process of photosynthesis occurs in chloroplasts whereas the process of respiration takes place in cytoplasm and mitochondria.

11.6 Gaseous exchange between Organisms and Environment

In aerobic respiration the organisms utilize the environmental oxygen to oxidize their organic compounds as a result of which carbon dioxide is produced. The carbon dioxide is toxic to the organism and it is, therefore, necessary that the organism should expel the carbon dioxide out of their bodies in some way.

The aerobic organisms in the process of respiration take up oxygen from their environment and eliminate Carbon dioxide from their bodies to the environment. This exchange of gases between the organisms and their environment forms the first phase of the aerobic respiration.

Gaseous exchange in animals

The gaseous exchange in different organisms occurs by means of different methods and organs.

In small aquatic animals like the unicellular protozoa the dissolved oxygen of water diffuses directly through their cell surface into the interior of the animal and the carbon dioxide similarly diffuses out from their bodies into the external water. This is the simplest way of gaseous exchange and it can occur only in small animals with a diameter of less than one millimeter. Such animals have greater surface area to volume ratio and have low rate of metabolism.

As the animals grew in their size, their skin or external body surface become impervious to water. Thus it made the gaseous exchange impossible through diffusion. In large animals therefore, certain organs were developed through which an efficient exchange of gases could occur. The moist vascular skin, gills, lungs and tracheoles are the respiratory organs of different animals. These large animals have developed blood vascular system which transport oxygen from the respiratory surfaces to the deep cells and tissues in all parts of the body. The blood in all animals has some respiratory pigments which can bind oxygen and thus carry large amount of oxygen efficiently from respiratory surface to the interior cells. It is necessary that respiratory surface is thin and moist because very little diffusion of gases, if at all, can occur through the thick dry surface. In aquatic animal, it is not all difficult to keep the respiratory surfaces moist and safe. But in land animal the respiratory surfaces are, therefore, usually situated deep down in the body and some pumping mechanism is used to force the air to this deeply situated respiratory surface.

Gaseous exchange through skin

The skin is kept moist and richly supplied with blood for the dissolved oxygen to diffuse from the external water to the blood and for the carbon dioxide to diffuse from the blood to the exterior water. In amphibia and fishes the gaseous exchange occurs through the skin besides through the gills or lungs. The frogs and tortoises breathe through the skin during their hibernation period.

Gaseous exchange by gills

The gills are very effective for gaseous exchange in aquatic animals. Some animals have external gills which project out of the body of animals. These gills have very thin and highly vascularized surfaces e.g. the dermal papillae of starfish and arthropods.

In fishes the gills are present in the branchial cavity present on lateral sides of the body behind the head, this branchial cavity is covered over by an operculum. There is a counter current flow of water and blood in gills which ensures maximum exchange of oxygen and carbon dioxide between the blood and the bathing water. Water enters through the mouth, flows over the gills and goes out of the body from the opercular aperture. (Fig.11.8)

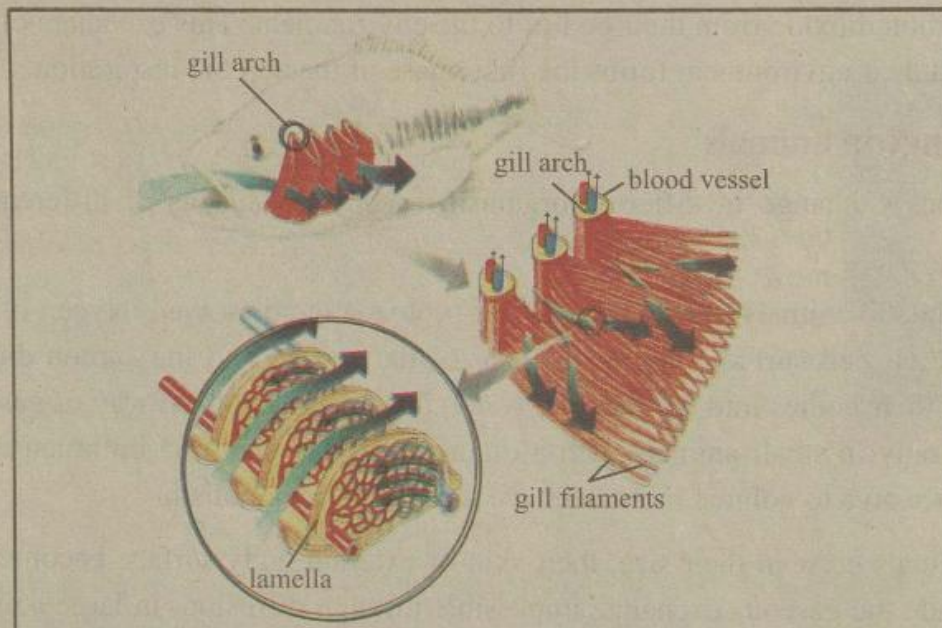


Fig. 11.8 Gaseous exchange in fish (gill filament, operculum bar)

Gaseous exchange in terrestrial animals

Gaseous exchange through trachea

Insects and other land dwelling arthropods (centipedes, millipedes, spiders) use tracheal tube for their gaseous exchange. This method is very effective and simple in which air can directly reach almost every cells of the body through small and minute tubes. These animals have a network of tubes called **tracheal tubes**. These tubes on reaching near the cells, are divided into very

Have you ever examined a fish closely? How will you know that the fish is fresh or not? If the colour of gills is red then it is fresh but if the colour of gills is changed, it is definitely not fresh. The red colour of the fish gills shows the presence of oxygenated blood.

If you closely observe any wasp or honey bee, you will see some change in their body you have noticed that their body move again and again. When it goes forward, its inner body cavity contracts and air is released when its stomach moves backward, then its cavity expands and air is inhaled.

minute tubes called **tracheoles**, whose terminal portions are filled with a fluid. The diameter of these tubes is less than a micrometer, the end of the tracheoles indent the membrane of the cells they supply. The external air enters into the large tubes of the tracheal system through **spiracles**. The oxygen from this air gets dissolved in the fluid present in terminal parts of tracheoles and diffuses into the cells. The CO_2 from the cell diffuses out into the fluid and is thus expelled out of the body along with the outgoing air. This is a very efficient and effective system of transport without the use of oxygen carrying pigments. (Fig.11.9)

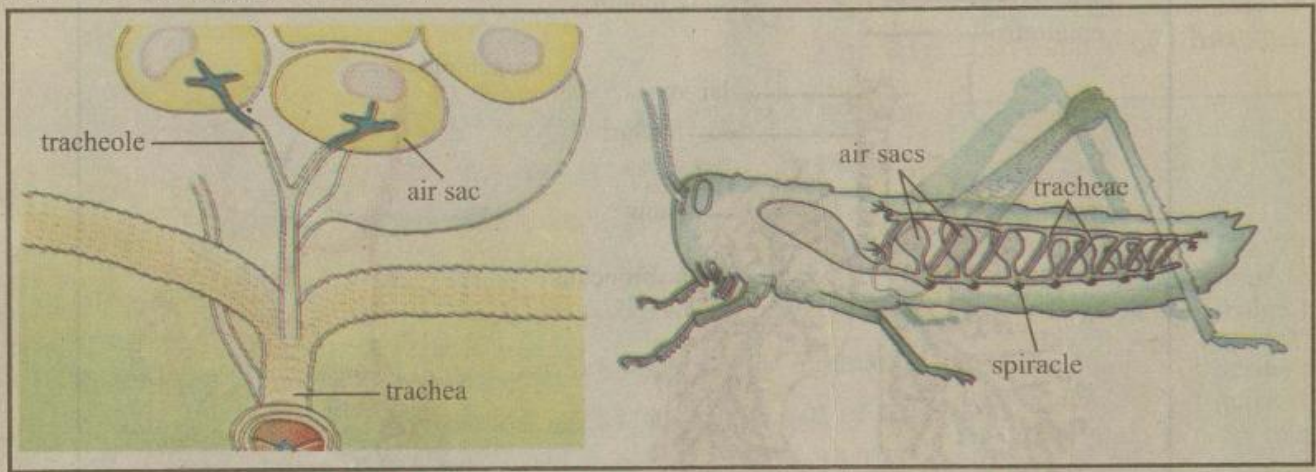


Fig. 11.9 Tracheal tubes and spiracles in insects

Gaseous exchange through lungs

In almost all the large land animals exchange of gases occurs through lungs. Some invertebrates e.g. snails, scorpions and spiders also possess lungs but in them there is no proper ventilating mechanism. In the vertebrates, the lungs are effectively and regularly ventilated.

In amphibia, simple and sac like lungs are found. The air is forced into the lungs in amphibia by the pumping action of the buccal cavity. The lungs in reptiles, birds and mammals have become more efficient. In them the respiratory surfaces has increased manifold by the formation of alveoli. Mammals have highest increase in their respiratory surface. According to one estimate the respiratory area in man is from 50-90 square meters which is 50 times the surface area of the body. A man has one thousand kilometer long capillaries.

The nature has made the functioning of birds lungs very effective. In addition to lungs, birds have air sacs which are filled on breathing by 75% of the inhaled air which by pass the lungs. The lungs first receive 25% of the fresh air with which the gaseous exchange occurs on inhaling. As the air is exhaled, the air of the sacs which is still fresh pass through the lungs on its way to exterior and supplies oxygen to the blood and carries away carbon dioxide from the blood.

Structure of Human Respiratory System

A pair of lungs with associated structure and organ like nose, pharynx, larynx, trachea, bronchi and bronchioles form the respiratory system.

Nose

The air enters through the nostrils into the nasal. This is lined with mucous secreting epithelium and ciliated epithelium. The nostrils are lined with hairs. The nasal cavities, located above the oral cavity and behind the nose are covered with epithelial tissue.

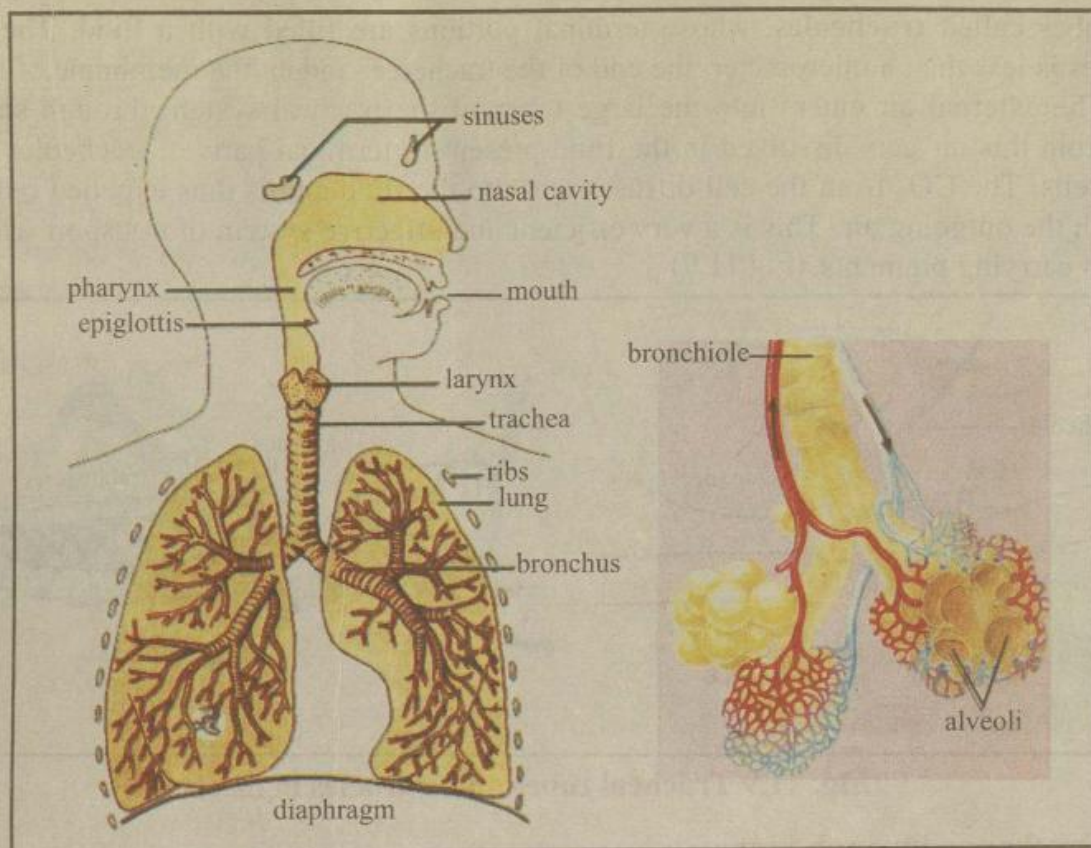


Fig. 11.10 Respiratory system in human

The beating of cilia creates a current in the mucus that carries the trapped particles towards the back of the nasal cavity. From here the mucus drips into the throat and is swallowed. Mucus keeps the nasal chamber moist. As the air passes through the chamber on its way to the lungs, dust particles and foreign substances in the air get trapped in the hair and the mucus. The air gets warmed to body temperature and is also saturated with moisture.

A number of cavities called **sinuses** open into the nasal cavity. The sinuses are lined with mucus-secreting epithelium. The opening of sinuses into the nasal cavity are very narrow. If these apertures are closed due to cold or inflammation, the sinuses get filled up with mucus which may produce headache etc.

Pharynx

The thin compartment of the nasal cavity opens into the pharynx (throat) by means of two small apertures which are called internal nares. The pharynx is a muscular passage way which extends from behind the nasal cavities to the opening of oesophagus and larynx. The air goes from the pharynx into the larynx.

Larynx

The upper most part of the air tube (trachea) is called the **larynx**. The larynx is a box made of cartilage. Two fibrous bands called **vocal cords** are located in this box which on vibration by the air produce sound waves which form the basis of human voice. This box is, therefore, also called **sound box**.

In cases of extreme emergency when the upper air passage is blocked by a foreign object to the extent that a victim cannot breathe, quick action is required to save a person's life. To force such an object out of the air passage, a sudden application of pressure to the abdomen forces air out, clearing the respiratory passage.

The air enters into the larynx through a small aperture which is called **glottis**. This opening is guarded by a muscular flap called **epiglottis** which fits into this opening while the food is being swallowed into the oesophagus lying behind the tracheal tube. This act is very important as it prevents the food from entering into the trachea and choking it.

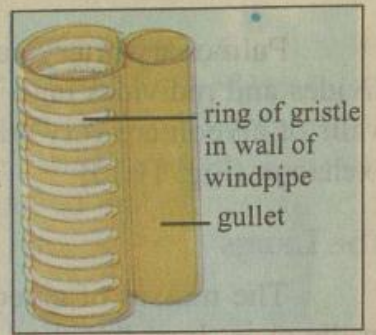


Fig. 11.11 Structure of pharynx

Trachea

The air tube which is known as trachea is about 12 cm long by cylindrical tube which lies in front of the oesophagus. There are incomplete shaped cartilagenous rings which are regularly placed in its wall and all along its length. These rings prevents the collapsing of the tube and thus keep the air passage wide open all the time. Trachea is also lined with ciliated mucous epithelium. Any foreign particles will present in the entering air get trapped in the mucous which is moved out of the trachea by beating of the cilia in the upward direction. (Fig. 11.11, 11.12)



Fig. 11.12 Trachea and gullet

Bronchi

The trachea on entering the chest divides into two smaller tubes which are called **bronchi** (single bronchus) which are similar in structure to the trachea but are smaller in diameter and they have in their walls small irregular cartilagenous plates. Each bronchus enters into the lungs of its own side. The right bronchus branches into three left bronchus divides into two secondary bronchi which serves the 3 right and 2 left lobes of the lungs respectively.

Explain what would happen if the cartilage supports of the trachea were of solid rings all the way around the trachea and a person swallowed a large mouthful bolus.

Bronchioles

The secondary bronchi divide into smaller and smaller branches until they end in thousands of passage ways called respiratory bronchioles. The bronchioles have not cartilagenous plates in their walls.

Alveoli

The walls of the respiratory bronchioles have clusters of tiny branches (like bunches of grapes) that along with the respiratory bronchioles are the sites of gaseous exchange, these pouches or air sacs are called alveoli (single alveolus). The alveoli are enormous in number. Every lung has about three hundred million alveoli.

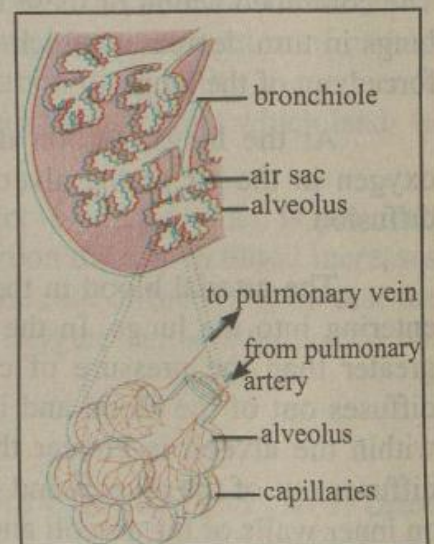


Fig. 11.13 Alveoli

Pulmonary artery carries impure blood from the heart and enters into each lung and there it divides and redivides until it forms a network of fine capillaries over the wall of each alveolus. The walls of alveoli are very thin (1/1000 mm thick) and moist and thus offer a very efficient site for gas exchange.(Fig. 11.13)

The Lungs

The masses of alveoli constitute lungs and their lobes. The lungs and the heart lie protected in the chest box, the chest box is formed on sides and in the front by the ribs and the intercostals muscles, and by a dome shaped muscular diaphragm on its posterior.

The lungs are enclosed in a double layered membrane called **pleural membrane**. There is a thin film of fluid in between the two layers. This watery fluid makes the movements of the lungs (expansion & contraction) easy.

Mechanism of Breathing

Breathing is spread over two phases:-

1. **Inspiration**
2. **Expiration**

1. Inspiration

During inspiration the dome-shaped diaphragm contracts flattening somewhat and thereby lowering the floor of the thoracic cavity. The external intercostals muscles contract raising the rib cage. A combined action of these two events expand the thoracic cavity, which in turn expands the lungs. As a result of it the air pressure within the lungs decreases. Thus air from the environment outside the body is pulled into the lungs to equalize the pressure of both sides. (Fig. 11.14)

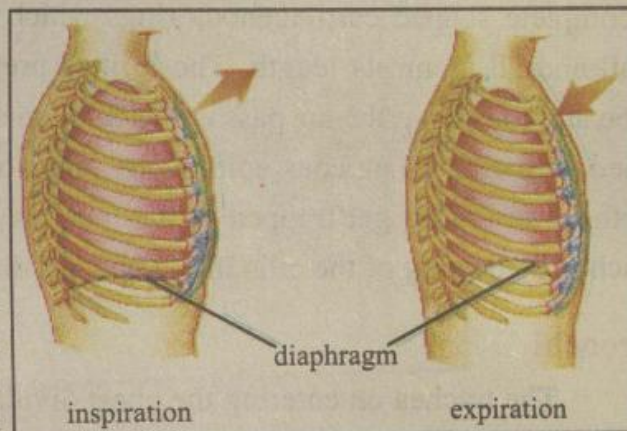


Fig. 11.14 Respiration in human

2. Expiration

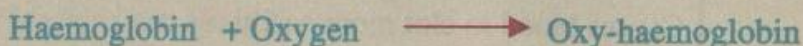
In expiration the external intercostals muscles relax and the internal intercostals muscles contract as a result of which ribcage drops. The diaphragm relaxes and assumes dome like shape. The combined action of these two events reduces the volume of the thoracic cavity. The volume of lungs in turn decreases which results in an increase in the air pressure in the lungs. The air is thus forced out of the lungs.

At the lungs, carbon dioxide within the blood of capillaries surrounding the alveoli and oxygen in the air of the alveoli are exchanged. The exchange of gases works by the process of diffusion.

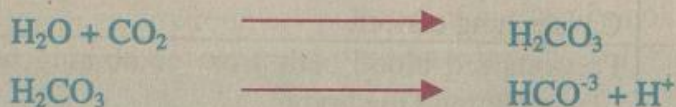
The arterial blood in the lungs has less oxygen and more carbon dioxide as compared to air entering into the lungs. In the deoxygenated blood of the lungs the pressure of carbon dioxide is greater than the pressure of carbon dioxide in the air within alveoli. Therefore, carbon dioxide diffuses out of the blood and into the alveoli. On the other hand, the pressure of oxygen in the air within the alveoli is greater than the pressure of oxygen in the arterial blood. Therefore, oxygen diffuses out of the alveoli and into the blood. The oxygen first dissolves in the film of fluid present on inner walls of the alveoli and then diffuse into the blood through thin walls of alveoli. The carbon dioxide of the blood diffuses out into the air of the alveoli by passing through the walls of the alveoli.(Fig. 11.14)

In man and other animals (all vertebrates and some invertebrates) some respiratory pigments are present in blood which can transport greater amount of oxygen efficiently from lungs to the other parts of the body. If it was not for the presence of haemoglobin in the blood, the oxygen transport could have been very slow and small in amount because only a small amount of oxygen can dissolve in haemoglobin. Whereas, according to an estimate one hundred ml of haemoglobin containing blood can transport about 20 ml of oxygen.

Oxygen does not combine covalently with haemoglobin. It is only loosely attached with haeme of the haemoglobin and is therefore forms oxyhaemoglobin but not haemoglobin oxide. This loose combination of oxygen with haemoglobin makes the detachment of oxygen at tissue level easy.



Carbon dioxide is transported from the tissues to the lungs mostly (by) bonded with water in the blood which first form carbonic acid with water that quickly dissociates into HCO^{-3} and H^{+} ions.



A small percentage (25%) of carbon dioxide combines with haemoglobin to form carbamino compound. Only a very small amount (6%) of carbon dioxide is simply dissolved in the blood.

Table 11.2

Gas	Inspired Air	Expired Air
Oxygen	21%	16%
Carbon dioxide	0.04%	4%
Nitrogen	79%	79%
Water vapour	Variable	Saturated
Temperature	Variable	About body temperature
Dust particles	Variable	Little, if any

Effect of exercise on the rate of breathing

A man breathes 16 times a minute in normal circumstances. The rate of breathing is controlled by a center in the brain which is very sensitive to the changing concentration of carbon dioxide in blood. In case of higher concentration than normal of carbon dioxide this center sends impulses directly to the diaphragm and intercostals muscle to contract at a faster rate which leads to an increase in the rate of breathing.

When you do hard work or take strenuous exercise you need more energy which is provided by more and more oxidation of glucose. As a result the amount of carbon dioxide in blood increases which stimulates the carbon dioxide centre in the brain to enhance the rate of breathing so that the excess carbon dioxide from the blood can be eliminated and more oxygen can be supplied to the fastly metabolizing muscles.

Bad effects of smoking on health

Smoking is very harmful to human health. The smoke contains chemicals and gases. Dried tobacco leaves are used in cigarettes. The tobacco on burning produce a number of dangerous and toxic compounds which have been shown in a following flow chart.

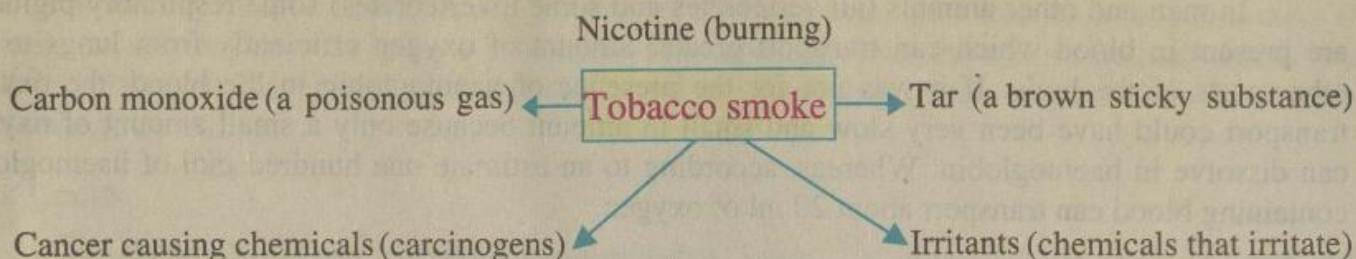


Table 11.3 Harmful chemicals present in the cigarette smoke

Chemical	Harmful effects
Nicotine	Man is addicted to cigarette damages brain tissues. Causes blood to clot more easily. Hardens walls of arteries.
Tar	Kills cells in air passages and in lungs. Increases production of mucous and phlegm in lungs. Causes lung cancer.
Carbon monoxide	Prevents red blood cells from combining with and transporting oxygen around the body.
Carcinogens	Promote the growth of cancerous cells in the body.
Irritants	Irritate air passages and air sacs in the lungs. Kill cells at the surface of air passages Causes smoker's cough and lung cancer.

Diseases produced by smoking

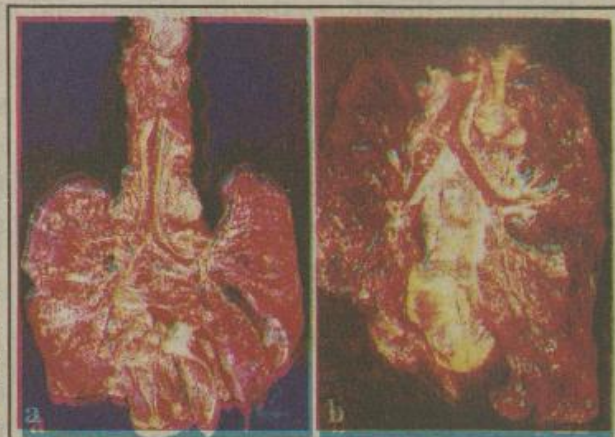
Smoking can produce the following diseases:-

1. Bronchitis

The smoking can produce inflammation of the respiratory or air passages like trachea, bronchi and bronchioles. This disease is called **bronchitis**. The attack of the disease is sudden and short lived but in chronic bronchitis, the attack is more frequent and of a long spell. The air passage gets narrow which produces difficulty in breathing. The chronic bronchitis can be fatal also. The cigarette smoke damages the ciliated epithelium due to which the foreign particles instead of being trapped and eliminated can go to the lungs and produce infection etc. The mucus is also secreted in greater quantity which can block the air passages and leads to repeated and continuous coughing. This is called **smoking cough**.

2. Lung Cancer

Cigarette smoke has frequently been reported to have produced cancer of lungs. Asbestos dust can also produce cancer. Cancer is a very dangerous and fatal disease which results from the disordered and uncontrolled cell division. The tar of the cigarette smoke has been reported to be the cause of cancer production. This chemical can damage the cells of internal epithelium of lungs and air tubes. This can produce cancer in the epithelium lining the air passages which can lead to thickening of their walls,



(a) Healthy lung (b) Cancerous lung

Fig. 11.15

ultimately blocking them. Small tumors can be destroyed by the white blood cells but when a tumor increase in its size it can spread by way of blood to other parts of the body. The early stages of cancer produces no symptoms, hence it goes on growing unnoticed till it has completely spread and at this stage it is no more curable and becomes fatal.

Lung cancer is very painful and dangerous. Its intensity usually has a correlation with the quantity of tar inhaled which in turn is related with the frequency of smoking. It has been found that smoking for 25 years with 20 cigarettes a day can produce lung cancer in the smokers. When the lungs of regular smokers were examined and compared with the lungs of non-smokers of the same age and sex, it was found that the smokers had developed lung cancer. The treatment of cancer consists in removing the cancerous parts of the body or destroying it through irradiation.

Bad social effects of smoking

The non-smokers are allergic to cigarette smoke as it produces irritation in their eyes and throats. The non-smoker, therefore, do not like the company of smokers. The non-smokers are also exposed to same risk as the smokers by living with them. The non-smokers can also develop cancer by continuously living in an environment polluted of cigarette smoke.

KEY POINTS

1. In respiration the organism get oxygen from the environment and transports it to their cells and the CO₂ formed in their body is given out to their environment. This is called breathing.
2. In cellular respiration the organic compounds in the living cells are oxidized with the help of enzymes. As a result a large amount of energy is utilized to make ATP molecules in mitochondria. ATP energy is used in carrying out various activities.
3. In aerobic respiration glucose is incompletely oxidized into alcohol or lactic acid. Less amount of energy is released in anaerobic respiration as to aerobic respiration. Also in this type molecular oxygen is not utilized.
4. For aerobic respiration all plants require oxygen which is obtained from the air or water. Oxygen in plants reaches the mitochondria through stomata and lenticells. Carbon dioxide is eliminated from the plants through the same route.
5. In small aquatic animals the exchange of gases occurs through diffusion from the body surface. In insects process is carried out by tracheal tube. Whereas in higher animals gills and lungs are used for respiration.
6. In mammals (man) the respiratory system consists of lungs and associated organ which includes nose, pharynx, larynx, trachea, bronchi, bronchioles and alveoli.
7. For inspiration the air pressure in the lung decreases as a result of which the air is sucked into the lungs to equalize the air pressure in the lungs and the outside.
8. Gaseous exchange taken place in the alveoli whose thin walls facilitate the exchange between the blood and the air. The oxygen is transported to various parts of the body in the blood as oxyhaemoglobin whereas carbon dioxide is transported from the tissues to the lungs in blood and is given out in the air in the alveoli.
9. In expiration the volume of the chest box is decreased which put pressure on the air in lungs which then moves out to equalize the pressure.
10. The rate of breathing is regulated by the amount of carbon dioxide in blood

which stimulated the respiratory center in the brain that control the rate of breathing accordingly.

11. The respiratory organs are delicate and vulnerable. Therefore, they need to be protected from pollution and toxic substances.
12. When polluted air enters the air passage ways it produces

inflammation thus narrowing the passageways. It also increases the mucous secretion and decreases the activity of cilia which leads to a great accumulation of mucous in the passageways and lungs leading to growth of germs as a result of which different diseases (cough, bronchitis and even cancer) are produced.

QUESTIONS

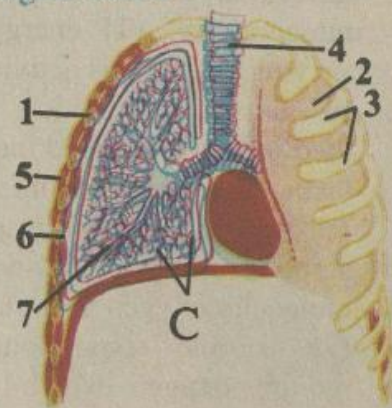
1. For the following questions four options have been given, encircle the correct answer.

- (i). Cellular respiration means:
 - (a). break down of starch to provide glucose
 - (b). release of energy from glucose
 - (c). diffusion of oxygen into the blood
 - (d). exchange of gases and water
- (ii). In which part of a human's respiratory system the air is not expelled during forced expiration?
 - (a). trachea
 - (b). bronchi
 - (c). bronchioles
 - (d). alveoli
- (iii). Which of the following is the direct cause of the increase in breathing rate after strenuous exercise?
 - (a). more oxygen is needed by the body tissues to pay off the oxygen debt.
 - (b). a fall in the oxygen concentration in the blood affects a control center in the brain.
 - (c). a rise in carbon dioxide concentration in the blood affects a control center in the brain.
 - (d). an increase in temperature causes an increase in breathing rate.
- (iv). The function of the pleural membranes is to:
 - (a). hold the lungs in their correct position in the cavity.
 - (b). help to increase the volume of the

cavity during respiration

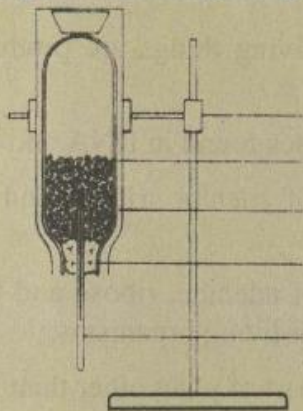
- (c). secrete a fluid enabling the lungs to slide on the thoracic wall.
- (d). help the diaphragm to increase or decrease the volume of the thorax.
- (v). Anaerobic respiration differs from aerobic in the fact that anaerobic respiration requires:
 - (a). no oxygen and releases more energy
 - (b). no oxygen and releases the same amount of energy
 - (c). oxygen and releases more energy
 - (d). no oxygen and releases less energy

2. In the figure below

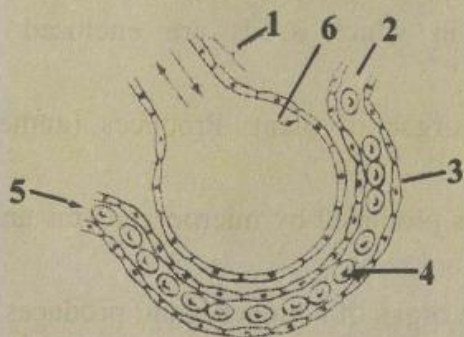


- (a). Name the parts labelled 1-7
- (b). What is the function of structure 'C'?
- (c). What is the function of structure found on part 4?
- (d). Which part is directly concerned with sound production?

3. Label the parts in the figure given below



- For what purpose this apparatus is used.
 - The temperature of the pea seeds
 - Rises in the day and drops a little each night, tell the reason.
 - Why is a vacuum flask used in this experiment? And placed it in an inverted position.
4. The figure below shows a diagram of an alveolus and its blood supply.



- Name the structure labelled 1-2
- Name the process by which oxygen and carbon dioxide enter and leave the blood at an alveolus.
- State three adaptations, shown in the diagram, which enable the alveolus to function efficiently.

5. Give short answer of the following questions

- What is the name of the substance which causes muscle fatigue?
- To what does the 7300 cal refer?
- What chemical substances have been mostly involved in the break down of the glucose molecule into smaller molecules?
- Write down the complete name of ATP and give two uses of energy.
- What product in the process of fermentation is necessary for bacrification?

6. Write an essay on cellular respiration.

7. How does gaseous exchange in plants take place.

8. What changes occur in intercostals muscles and diaphragm during inspiration and expiration.

9. How do insects breathe, explain their specific system.

10. Why there is no need of special respiratory system in *Amoeba* and protozoa.

11. Why we get tired after running fast?

12. Explain briefly the lung diseases caused by cigarette smoke and polluted air.

13. State the difference between aerobic and anaerobic respiration.

GLOSSARY

Abiogenesis	"Life from Non-Life". Living things are produced from non-living things.
Adenine	One of the nitrogenous bases found in DNA and RNA.
Adenosine diphosphate (ADP)	A compound consisting of adenine, ribose and two phosphate group.
Adenosine triphosphate (ATP)	A compound consisting of adenine, ribose and three phosphate group. Energy currency for living organisms.
Adventitious roots	Roots growing from any part of plant other than radical.
Aerobic respiration	Complete oxidation of glucose in the presence of oxygen.
AIDS	Abbreviation acquired immuno - deficiency syndrome. Viral disease destroy natural immunity against disease in human beings.
Alternation of generation	A life cycle of some plants that involve a multi-cellular monoploid generation alternating with a multi cellular-diploid generation.
Anaerobic respiration	Chemical break down of food in the absence of oxygen.
Alveoli	Small microscopic sacs of lungs for gases exchange.
Angiosperms	Groups of plants in which seeds are enclosed in fruits. Flowering plants.
Antheridium	Male reproductive organ of plant: Produces (antherozoids - sperm cells).
Antibiotic	Chemical substances produced by microorganisms and harmful for other organisms.
Archegonium	Female reproductive organ of a higher plant: produces egg cells.
Athlete's foot	A skin disease caused by fungus.
Autotroph	An organism capable of manufacturing organic nutrients from inorganic raw materials.
Bifacial leaf	Leaf having upper and lower surfaces.
Binary fission	The simplest form of asexual reproduction in which a unicellular parent organism divides into two equal cells.
Binomial nomenclature	The two word system that identifies each kind of organisms by use of its genus and species name.
Biochemistry	Study of chemicals of living organisms.
Bio-economics	Study of organisms with respect to economics particularly cost benefit relations.
Biogenesis	Origin of living organisms from other living organisms

Biology	Study of life (living things).
Biometry	Study of statistical analysis of data related to experiments.
Bio-technology	The industrial use of living organisms or their components to improve human health and food production.
Bronchi	One of pair of respiratory tubes branching from the lower end of wind pipe (trachea) into either lung.
Bryophytes	A group of land plants lacking vascular tissues that grows in moist places.
Cell	A basic unit of structure and functions of living organism.
Cell biology	Study of structure and function of different cell organelles.
Cell membrane	The structure that separates the interior of a cell from the surrounding environment and controlled the passage of materials into and out of the cell.
Cell wall	The rigid structure composed of cellulose that enclosed the cell of plants and various microorganisms.
Cellular respiration	The process by which energy stored in food is released by cells.
Circination	Rolling of leaves from their tips during initial growth conditions.
Coelom	A body cavity bounded entirely by mesoderm.
Coenocytic	A organism having more than one nucleus in a single mass of cytoplasm.
Compound leaf	Lamina of leaf is divided into small leaves or leaflets.
Crossing over	Exchange of parts between two homologues chromosomes.
Cyst	Unicellular organism covered with protective covering to resist against un-favourable conditions.
Deduction	A logical consequences of hypothesis based on experiment.
Dicot	A member of subclass of angiosperms (flowering plant) having two cotyledons in seeds.
Ecology	Study of environment and organisms in relation to environment.
Embryo	Generally contained within seed, egg or uterus.
Embryology	Study of development of embryo of living organisms.
Embryophytes	A group of multicellular plants (formation of plants from protected embryo). Bryophytes and Trachaeophytes.
Endosperm	A nutritive material in seed.
Endospore	A thick-coated resistant cell produced within a bacterial cell expose to unfavorable condition.

Eukaryotes	Organisms containing distinct membrane-bounded nucleus.
Expiration	Taking out of air from lungs.
Fermentation	Anaerobic production of alcohol, lactic acid or some similar compound from carbohydrates.
Ferns	Common and large group of pteridophytes.
Fossils	The remains or traces of an extinct organism.
Frond	Large compound leaf of fern.
Gametes	A sexual reproductive cell that fuse with another such cells before development begin; an egg or sperms.
Gametophytes	A haploid plant that can produce gametes.
Genetics	Study of the way in which characters are inherited.
Germ cells	Cells which form sex cells or gametes.
Gymnosperms	A vascular plant that bears naked seeds not enclosed in any specialized chambers.
Heterocyst	A specialized cell that engages in nitrogen fixation in some filamentous blue green algae.
Histology	The study of structure and arrangement of tissues of organisms.
Histoplasmosis	Lung disease caused by fungus.
Homologous organs	Organs in different species that are similar because of common ancestry.
Hypothesis	A possible explanation of an observed set of facts.
Infectious diseases	Diseases transmitted from one organism to another organism through various sources (air, touch, sputum, used utensils, clothes, injection syringes).
Inflorescence	A group of flowers on the same stalk.
Inspiration	Intake of air in lungs from outside.
Laryngitis	Infection of sound box (larynx).
Lenticels	A porous region in periderm of a woody stem through which gases can move.
Lichen	An organism formed by the symbiotic association between a fungus and a photosynthetic alga.
Lignin	A carbohydrate present in the cell wall of plant which provides strength to cell wall.
Malignant cancer	Quick spreading of cancer.
Meiosis	Cell division in diploid cells that results in haploid cells; reduction division.

Mitochondria	Oval membrane bounded organelles in which most of the reactions of cellular respiration occur.
Mitosis	The process by which nucleus of a cell divides, which maintain the chromosome number.
Mitotic apparatus	Spindle like structure along with aster formed during cell division.
Monocot	A flowering plant whose seeds have one cotyledon.
Morphology	Study of shape and form of living organisms.
Mycorrhiza	Mutalistic associations of plant root and fungi.
Mycotoxins	Toxic materials produced by fungus.
Non-septate	Multinucleated undivided hyphae and filament.
Nucleus	A large membrane bounded organelle containing chromosomes.
Oxygen debt	Shortage of oxygen for oxidation in muscles during exercise.
Paleontology	Study of fossils.
Pericardium	Protective membrane surrounding heart.
Pharyngitis	Infection of pharynx.
Pest control	Method of control to protect animals and plants from disease causing organisms.
Physiology	Study of functioning of living organisms.
Pleurisy	Infection of pleural membrane surrounding lungs.
Prokaryotes	Organism that lacks a membrane bounded nucleus.
Prothallus	Gametophytes of fern.
Protists	Simple mostly unicellular eukaryotic organisms.
Pteridophyte	Seedless vascular plants.
Pyrenoids	Organelle for storage of starch in chloroplasts of plants.
Rachis	Stalk of compound leaf on which pinnate or leaflets are attached.
Respiration	The process by which organisms obtain the energy they need by releasing chemical energy stored in nutrients.
Rhizoids	Structure, which is used for the absorption of water in non-vascular plant.
Ribosomes	An organelle that is the site of protein synthesis in a cell.
Ring worms	Skin disease caused by fungus.
Soft wood	Gymnosperm wood consisting of tracheids.
Somatic cells	All cells other than sex cells in the body of organism.

Species	Group of individual that can interbreed with each other producing fertile offsprings.
Spore	An asexual reproductive cell in plants.
Sporangium	A plant structure that produced spores.
Sporophyte	Spore producing diploid generation.
Tap root	Root developed from radical of embryo.
Taxonomy	Classification of organisms on the basis of their evolutionary relationship.
Tendrils	Long thread like structure of weak stem plants.
Thallophytes	Group of organisms having thallus plant body e.g. algae and fungi.
Thallus	A plant body showing relatively little tissue differentiation and lacking true roots, stems and leaves.
Tracheal tubes	Network of tiny air tubes in insects used for respiration.
Tracheophytes	A group of vascular plants containing xylem and phloem.

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